1
2776. 1)

Plan of method of adding
10 May 1837

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1

Plan of method of Adding
10 May 1837

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Plan of method of Adding

2

10 May 1837

Adding axis & wheels
without Framing

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Mss.

Mss. 2776.2)

2 Adding axis & wheels without framing 10 May 1837

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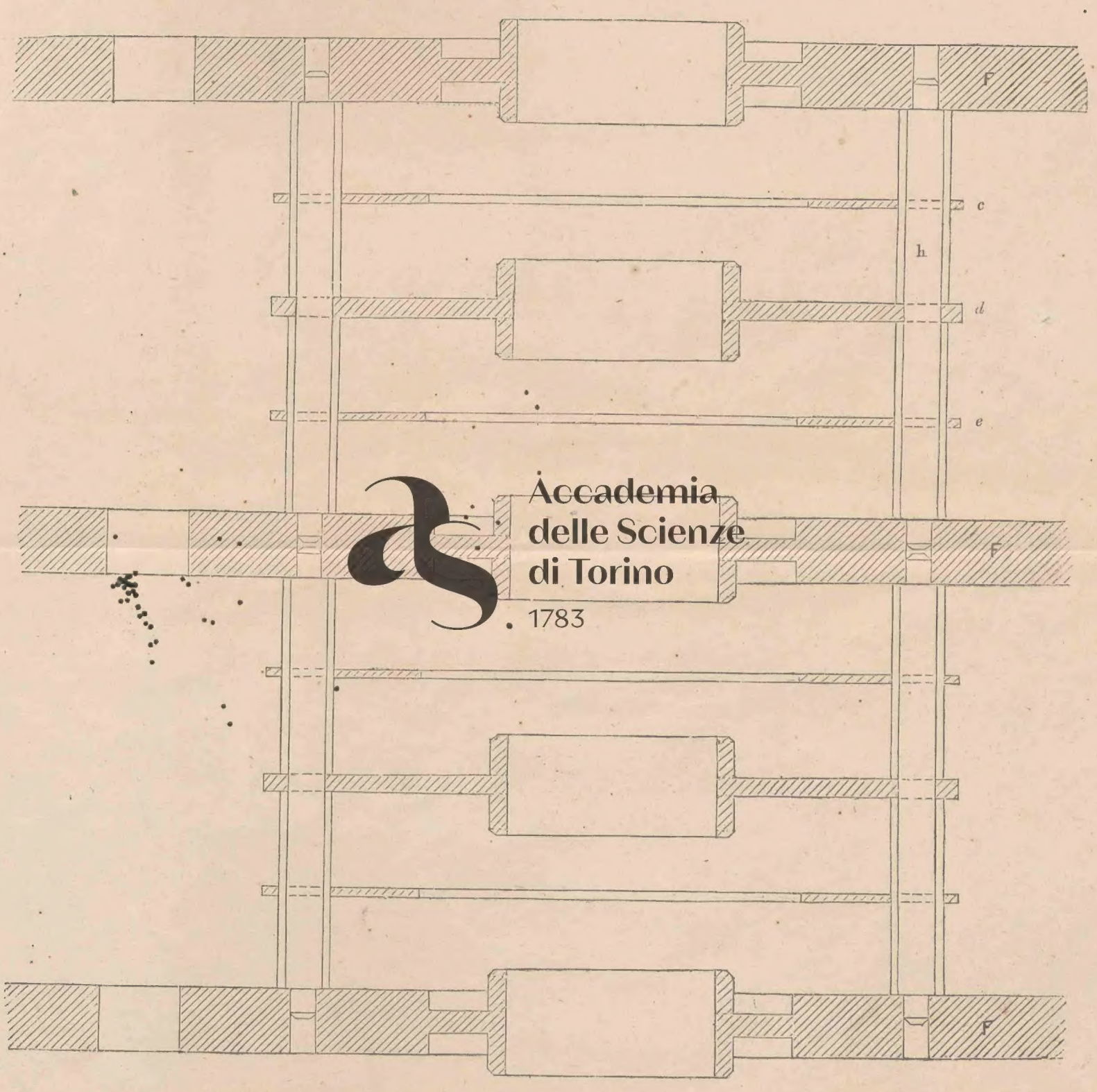
3

Frame of Adding Wheels

10 May 1837



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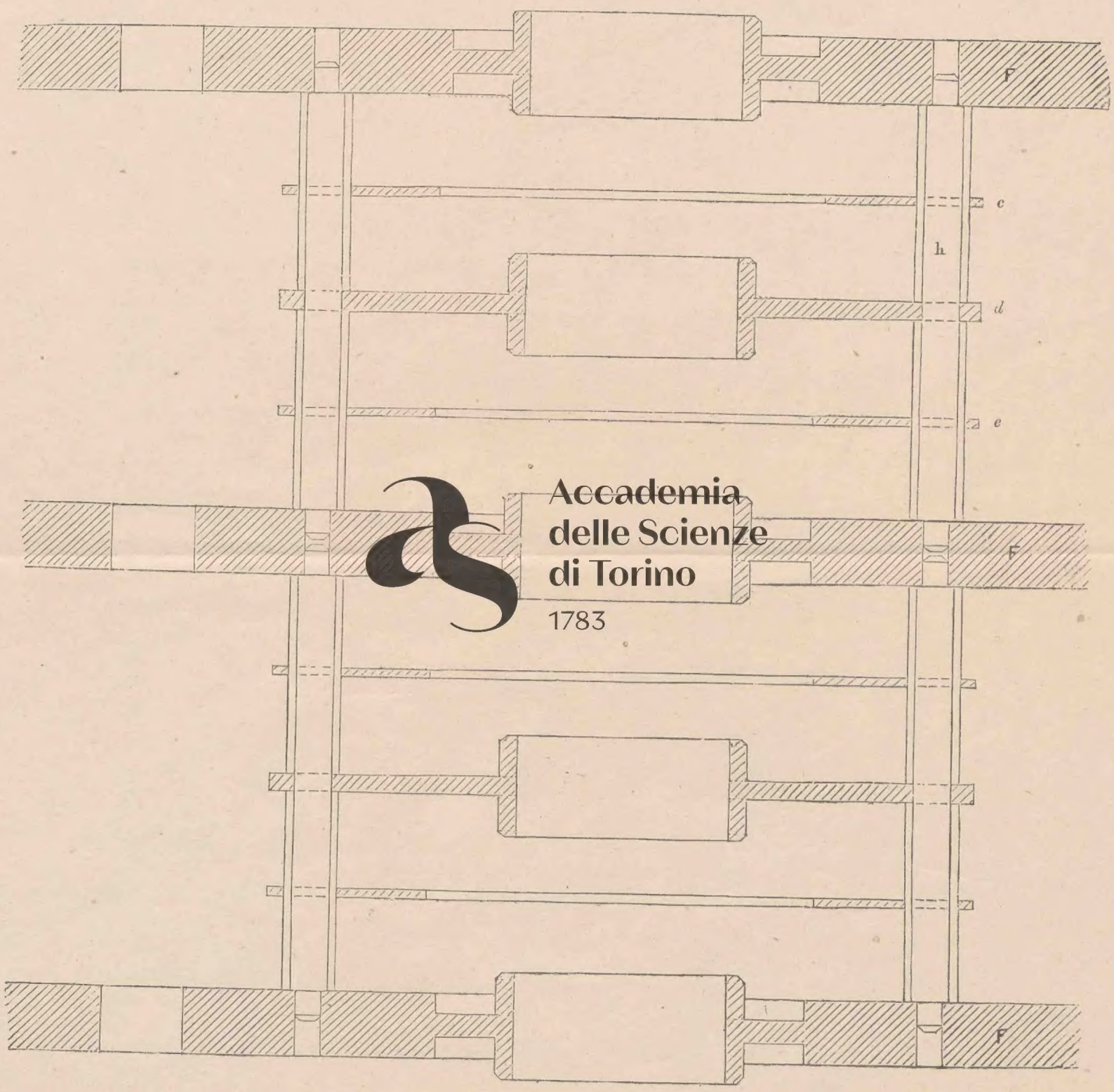
Mss. 2776.3)

Mss.

3

Frame of Adding wheels

10 May 1837



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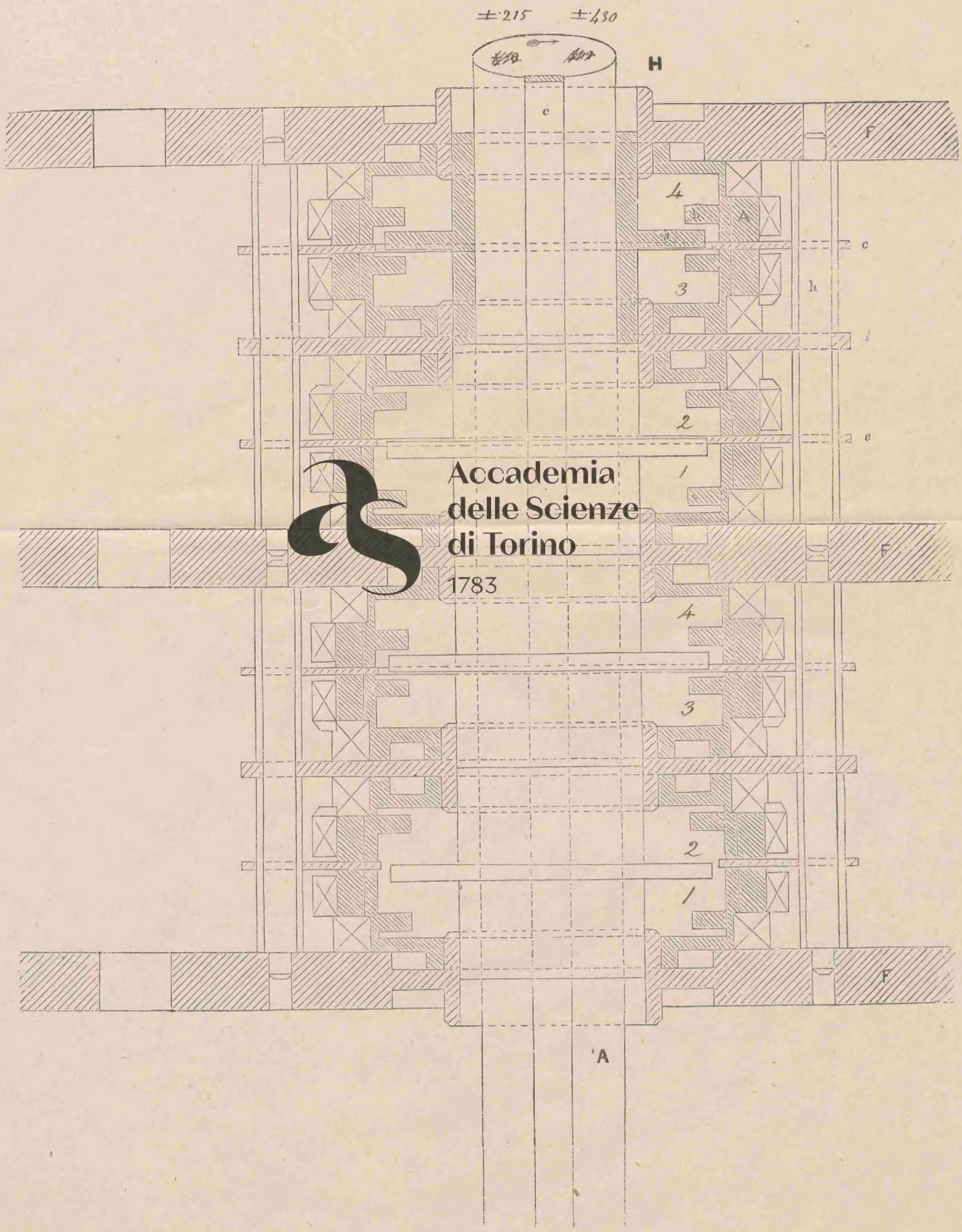
4 Section of Adding wheels & framing

10 May 1837



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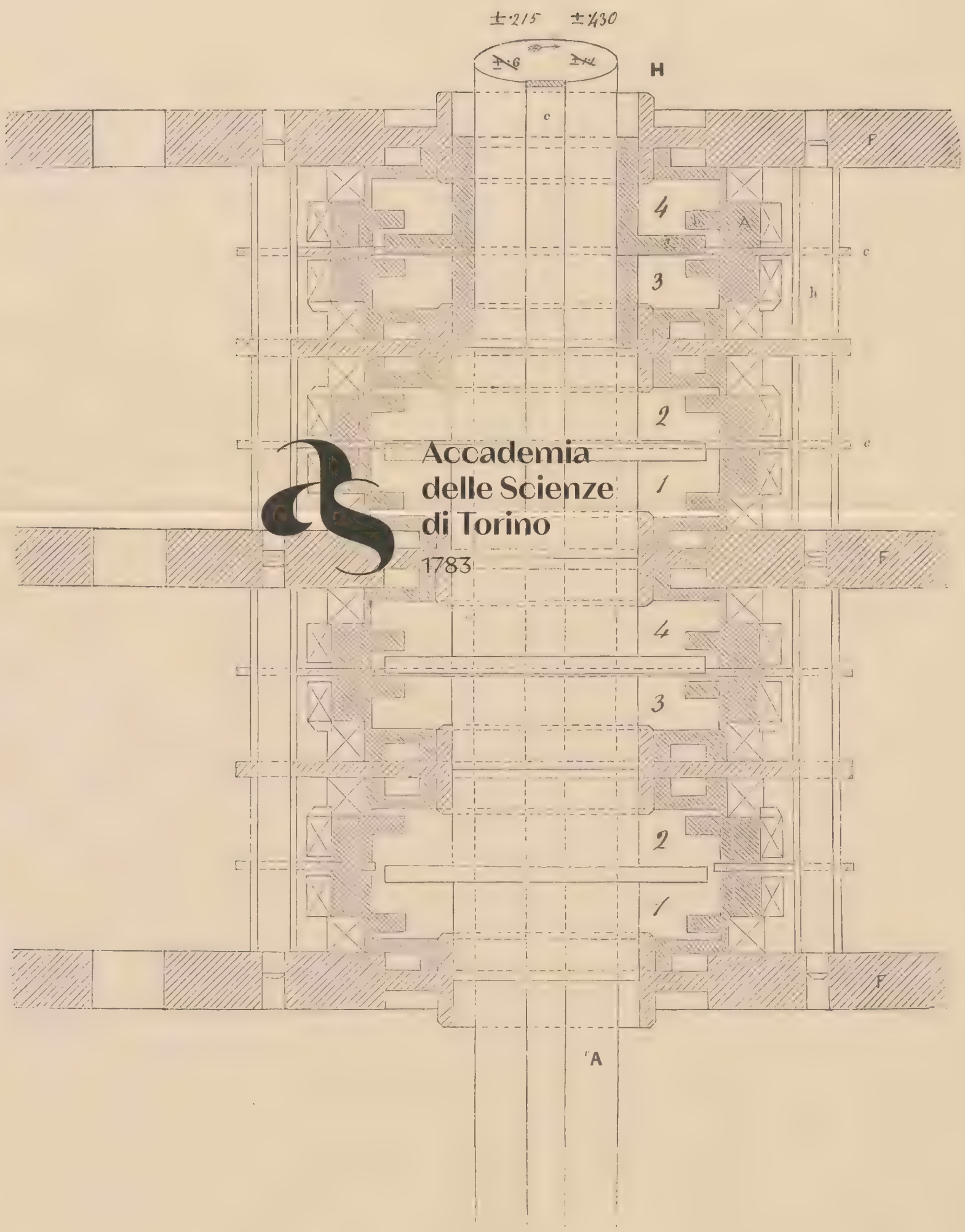
4 Section of Adding Wheels & Framing

10 May 1837



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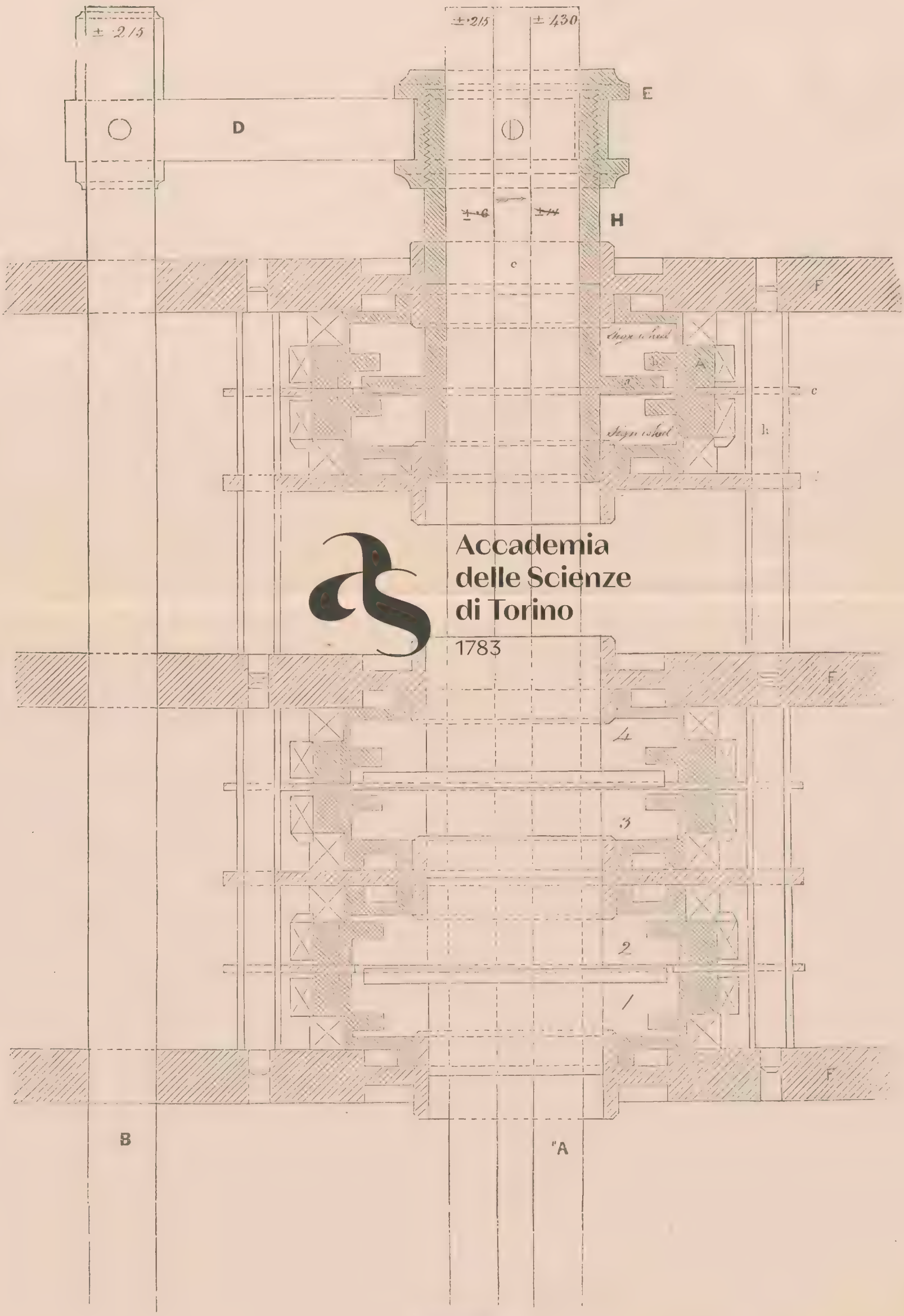
5

Section of Adding & Sign
Axes & wheels
Frames &c complete

10 May 1837



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5

Section of Adding & Sign,
Axes & Wheels,
Frames &c Complete.

10 May 1837

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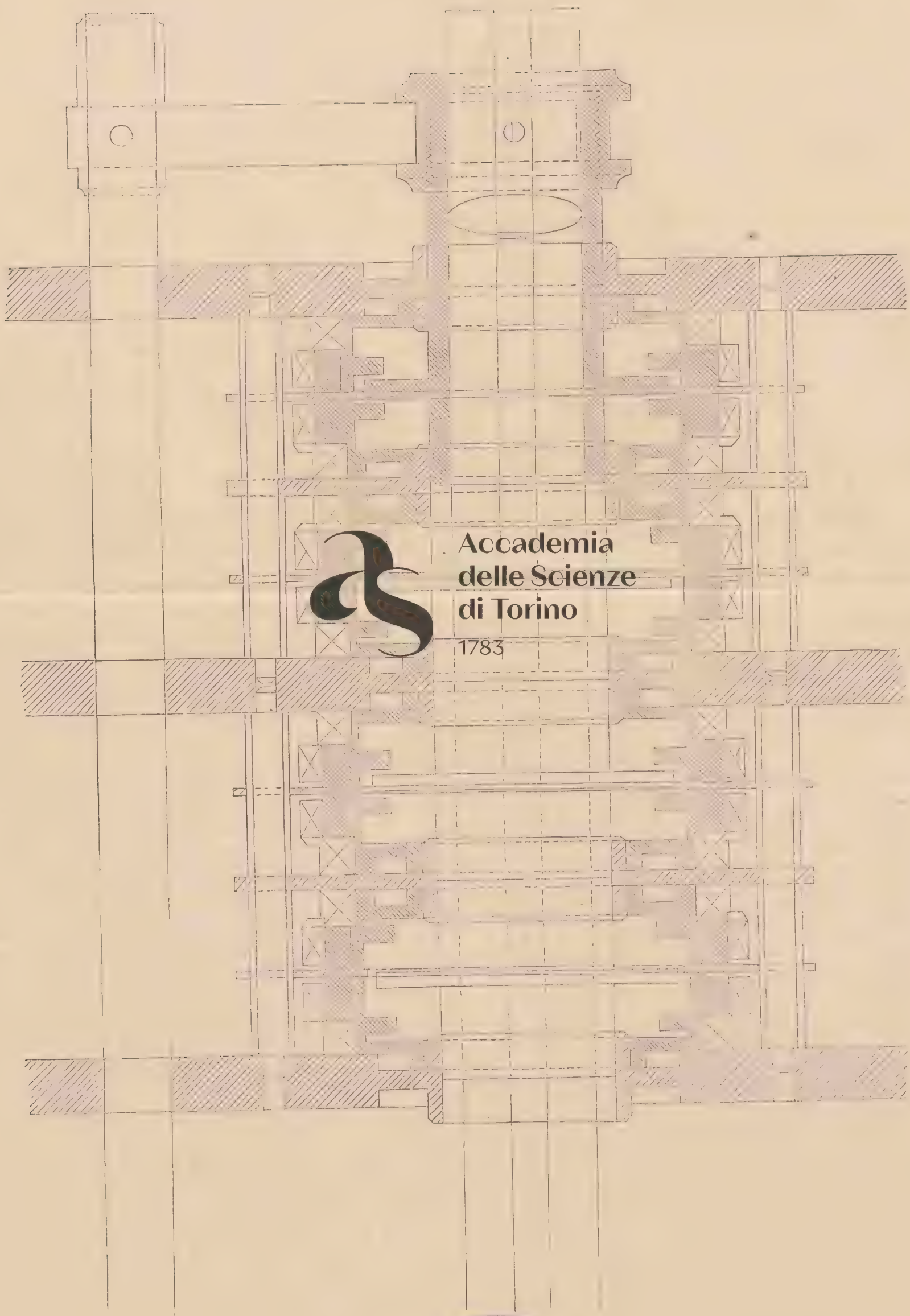
(1)

Impression from original wood cut from which No 7 is a stereotype plate with the letters & signs inserted

10 Mar 1837



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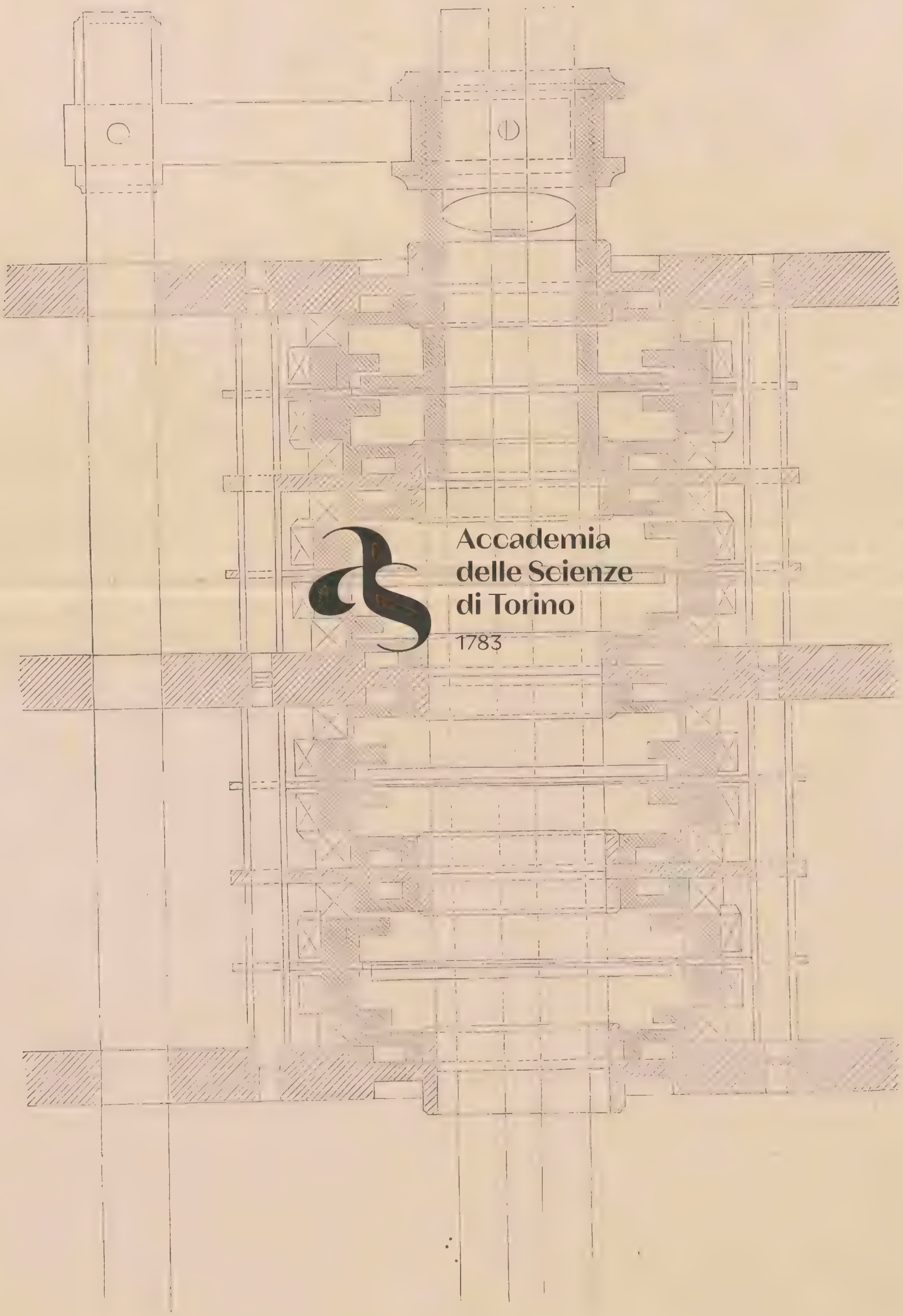
Mss. 2776. 6)

6

10 May 1837

Impression from original wood cut
from which No 7 is a stereotype plate with
the letters and signs inserted



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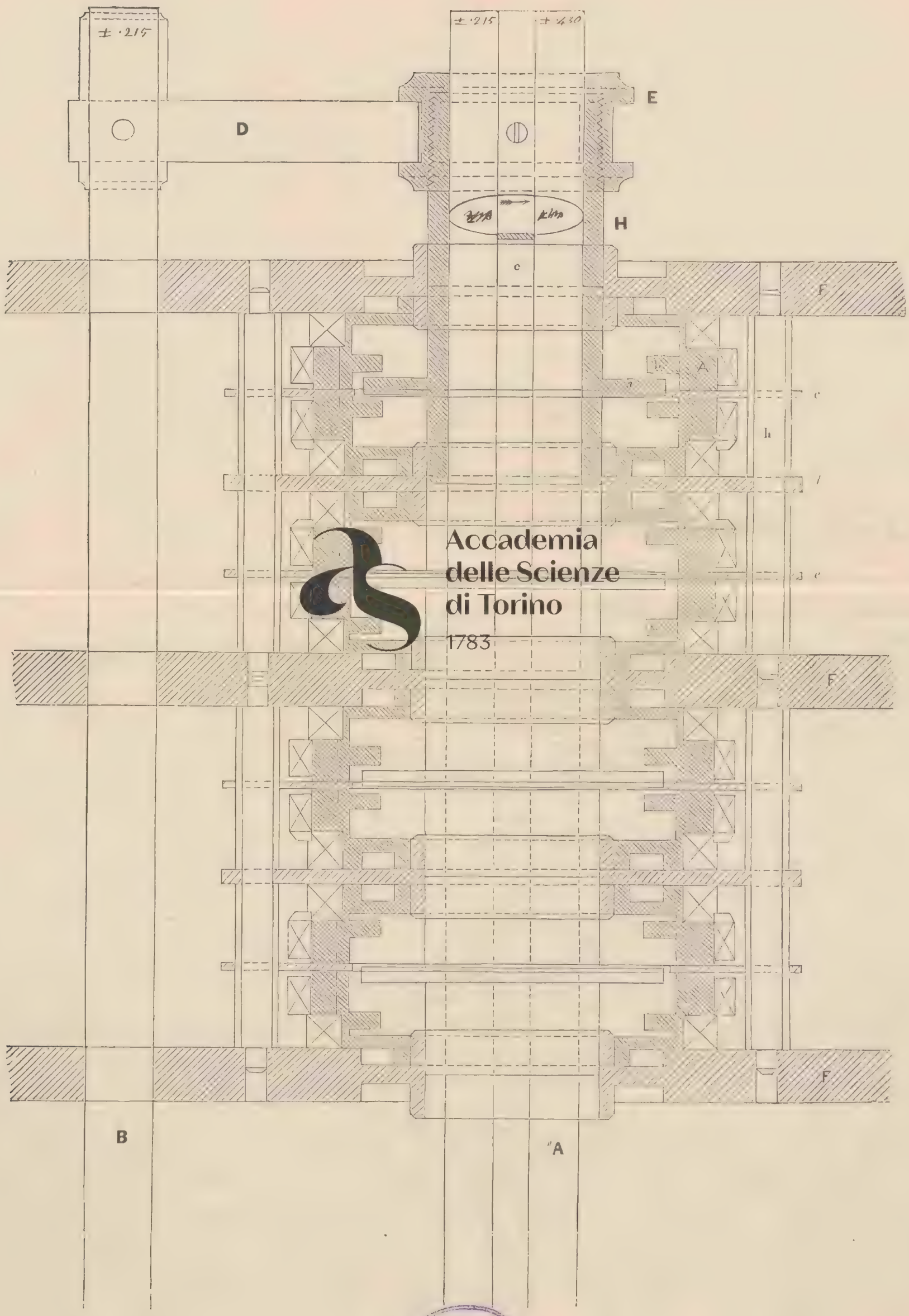
7

Stereotype cast from wooden block of No 6 with the letters & signs inserted

From these Stereotype plates No 2, 3, 4 & 5 were formed by scraping away portions of the lines

10 May 1837



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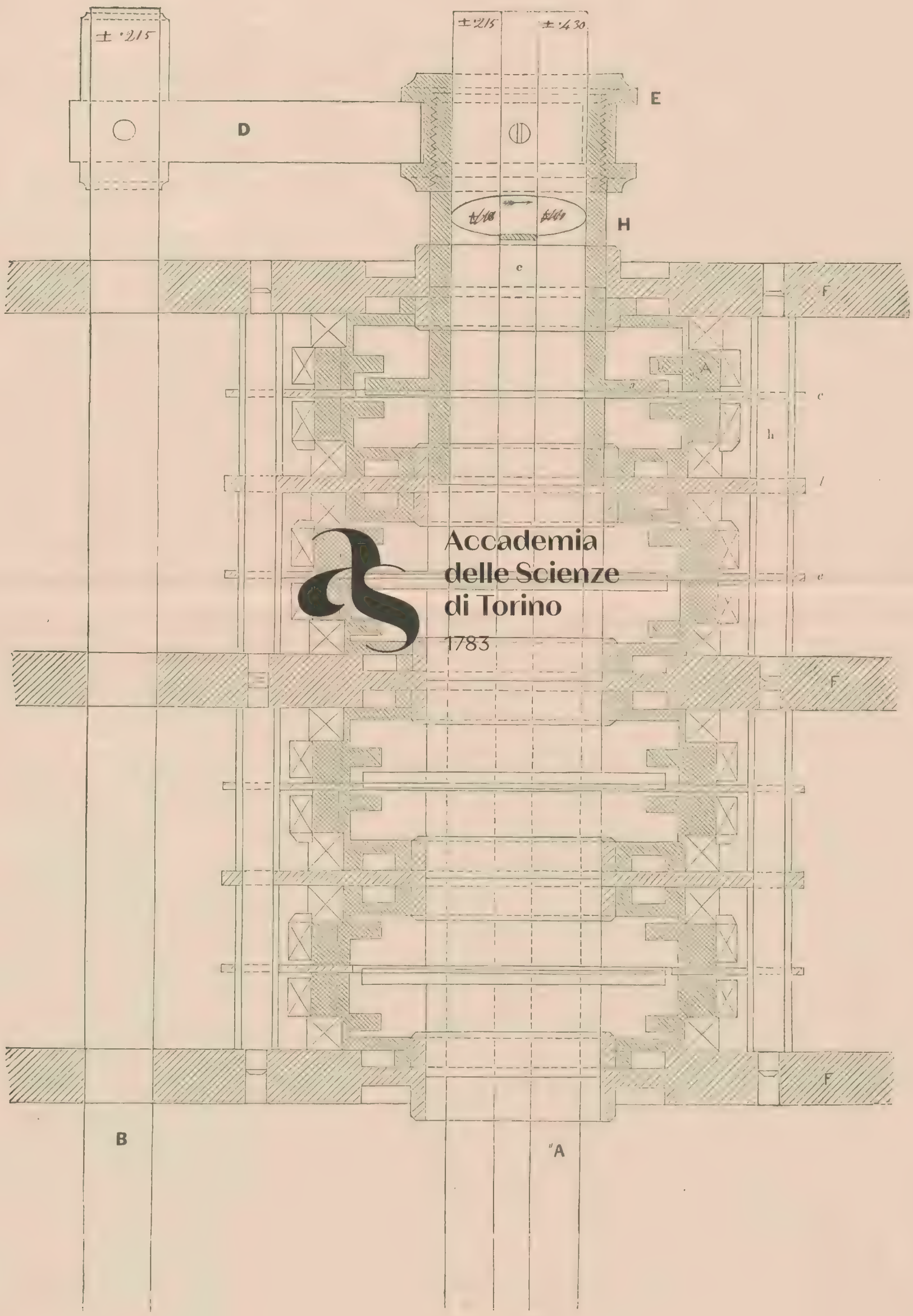
Mss. 277 (6.7)

7

10 May 1837

Stereotype cast from wooden block of No 6 with letters & signs inserted

From these Stereotype plates Nos 2, 3, 4 & 5 were formed by scraping away portions of the lines



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8

Plan of Adding wheels &
Long & short pinions

April 1837

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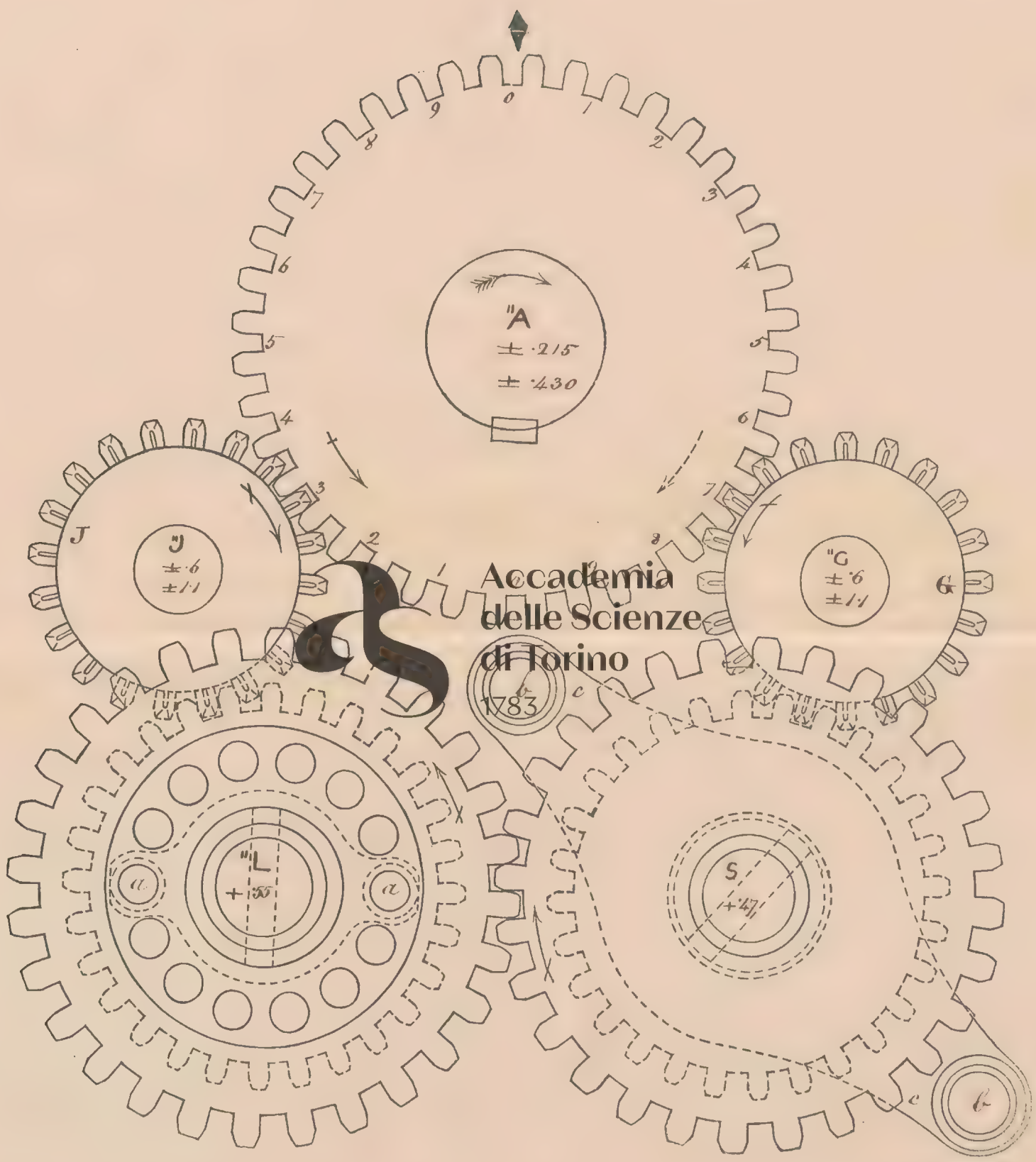
8

Cam for sliding wheels and Long & Short pinions

April 1837



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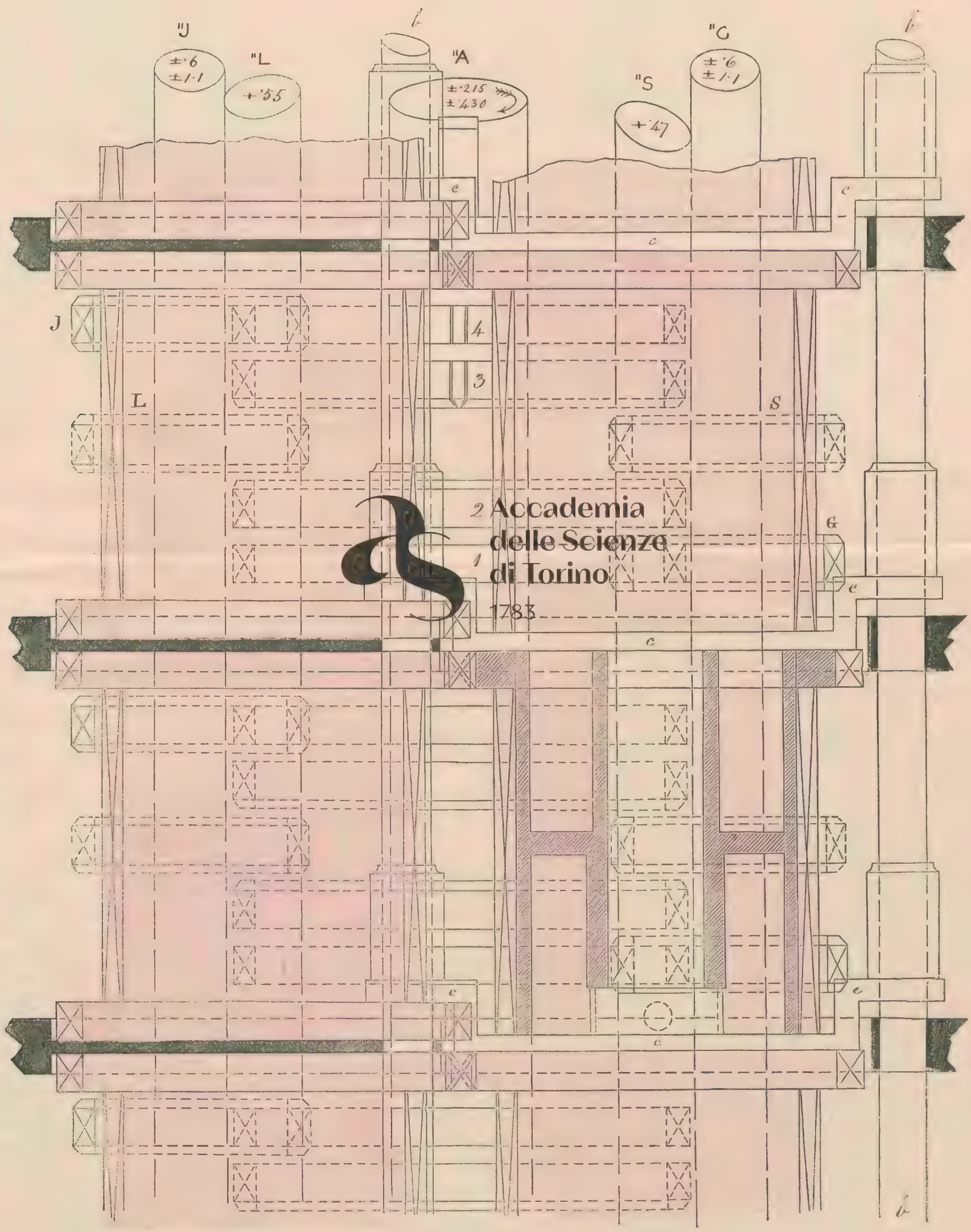
April 1837

Long Pinions in the position for Adding &c
Adding wheels & Short pinions behind Long Pinions



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2772(9)

Mss. 2776.9)

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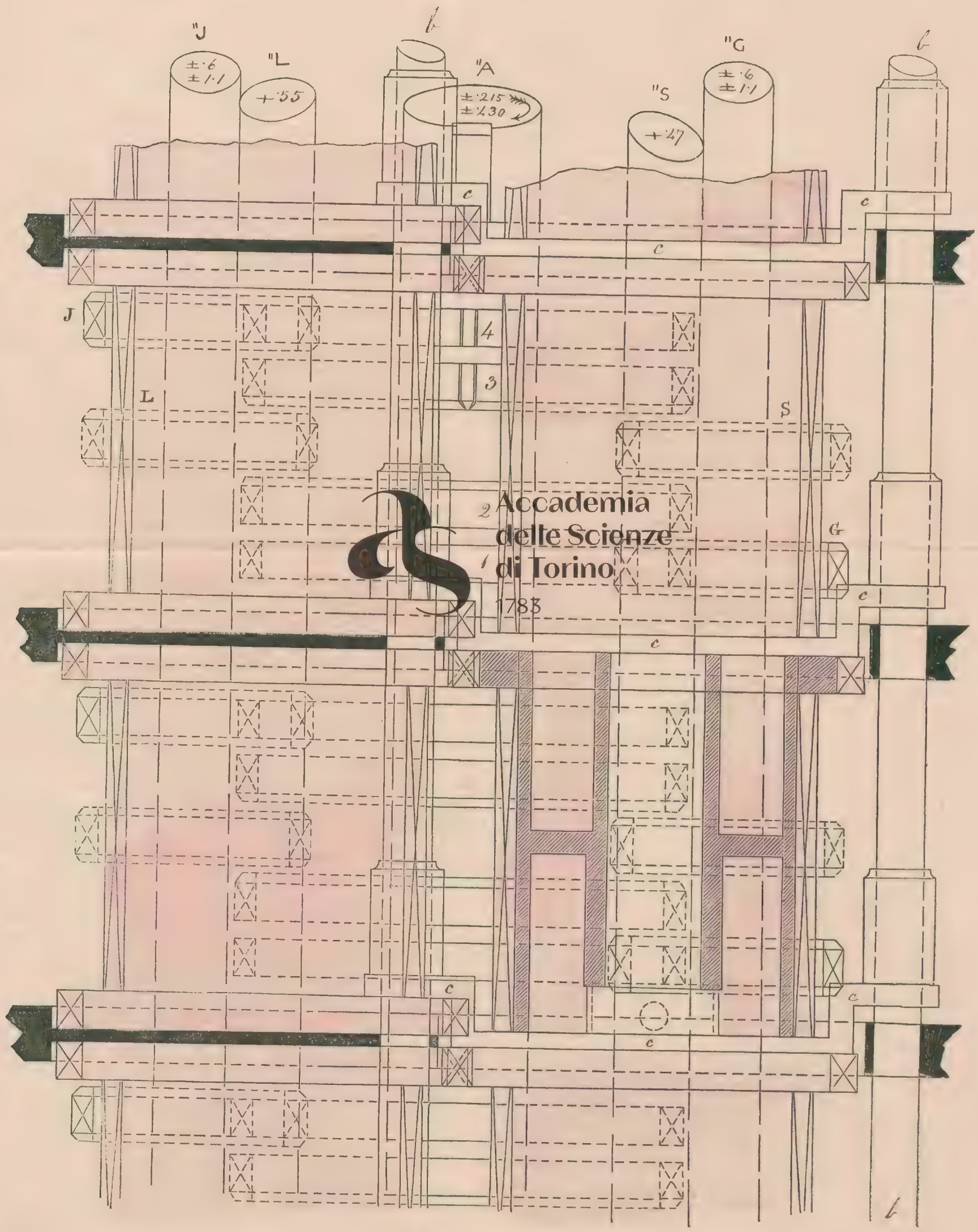
Long Pinions in the position for Adding &c
Adding Wheels & Short-pinions behind Long Pinions

April 1837



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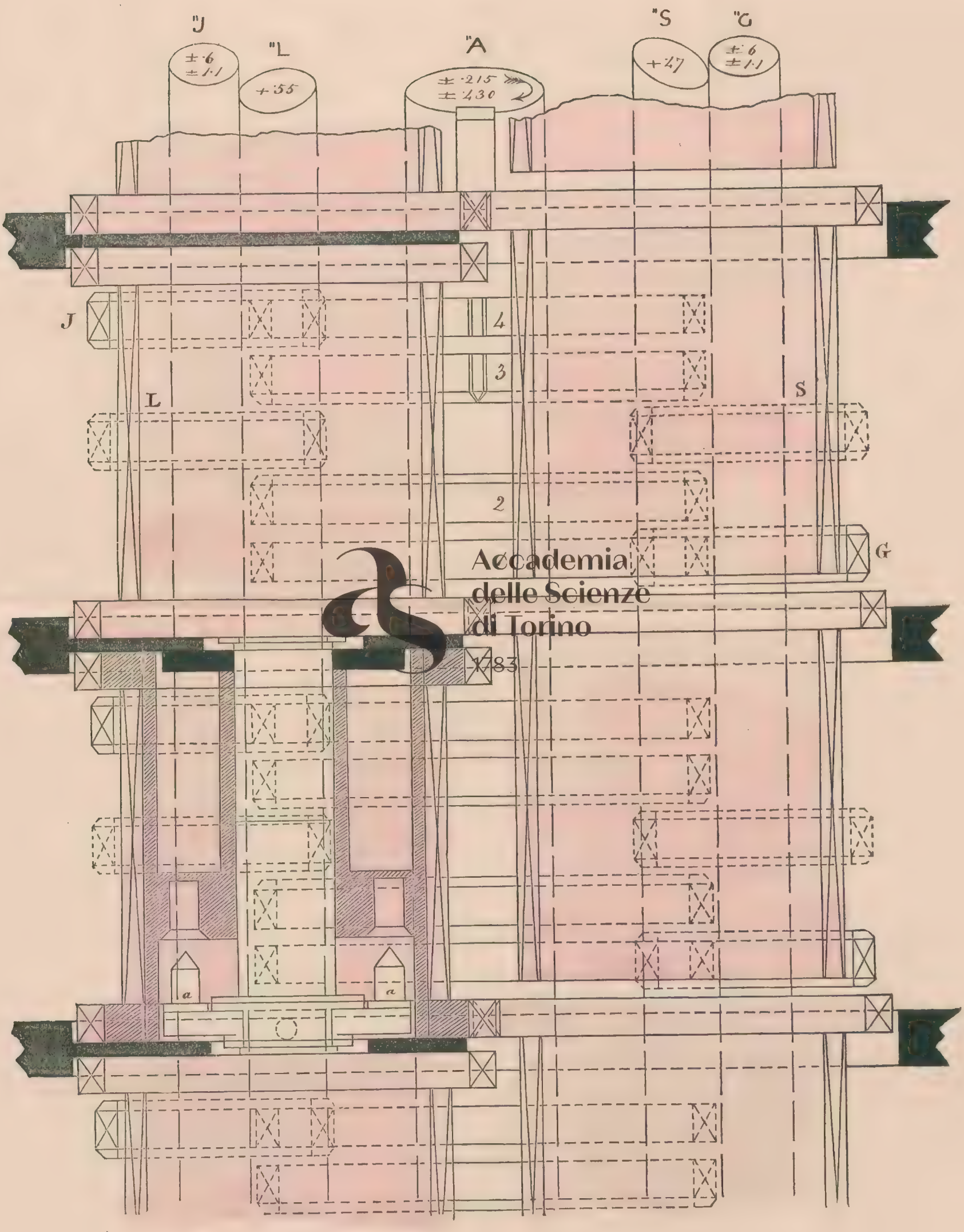
ACCADEMIA DELLE SCIENZE TORINO

April 1837

Long Pinions in the position for Stepping
adding wheels & Short pinions behind Long Pinions



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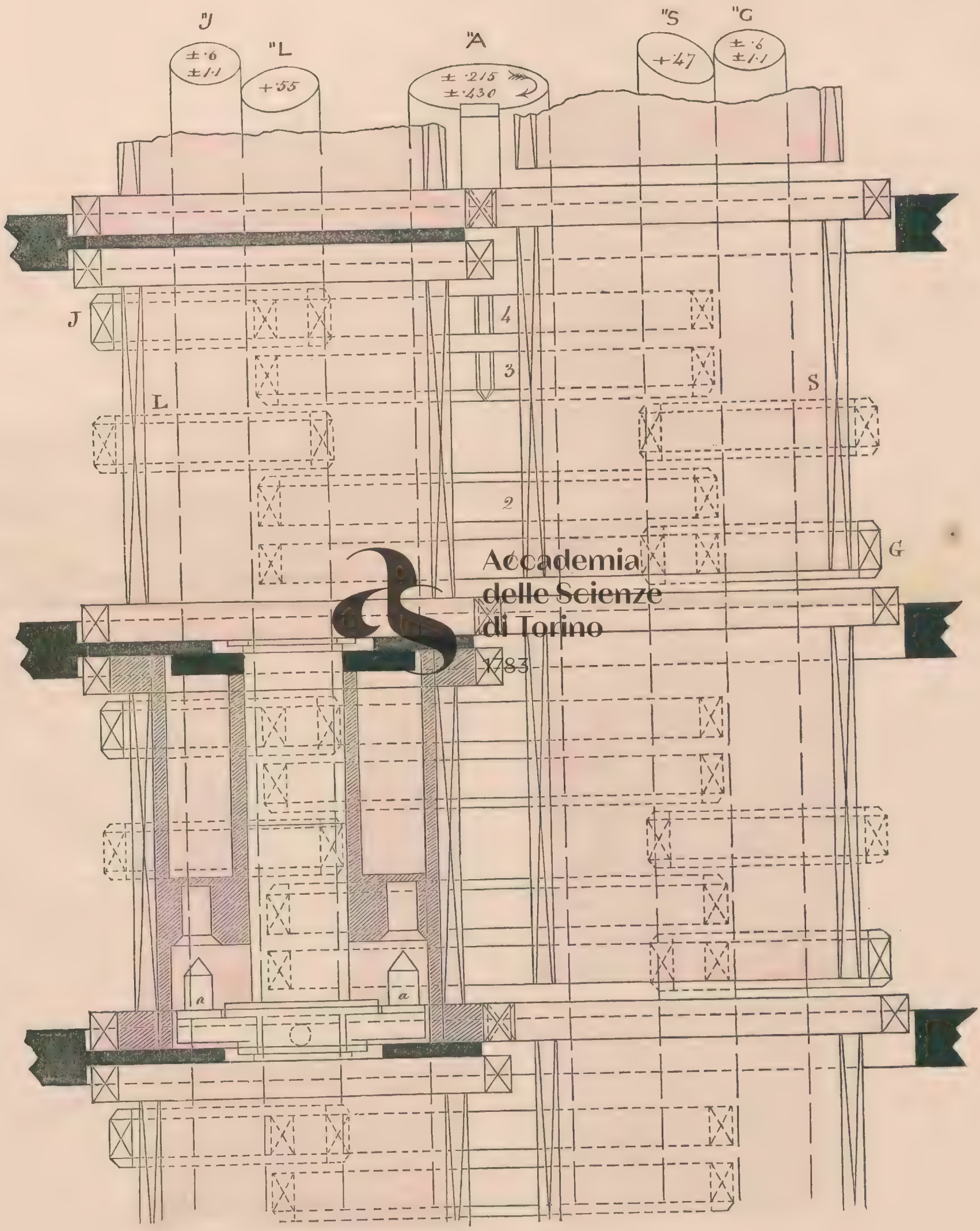
April 1837

Long Pinions in the position for Stepping
Adding wheels & Short Pinions behind long Pinions



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Plan of Carriage by Anticipation

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Plan of Carriage by anticipation

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12

Fixed & movable wires
of the anticipating carriage
$\frac{1}{3}$ the real wire

4 Dec. 1836

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N. ss. 2776.12)

Fixed & movable wires
of the anticipating carriage
$\frac{1}{3}$ the real wire

4 Dec. 1836

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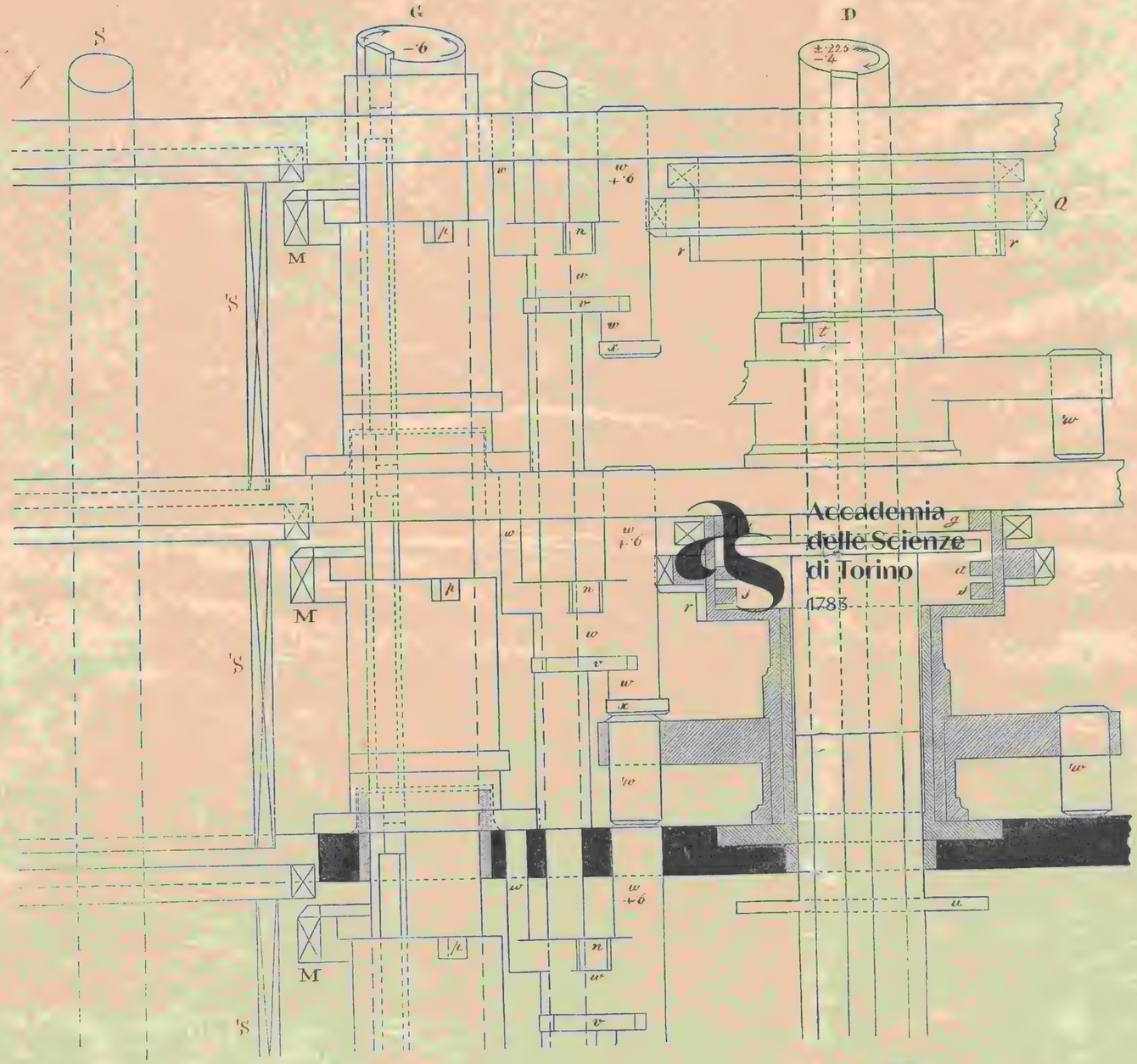
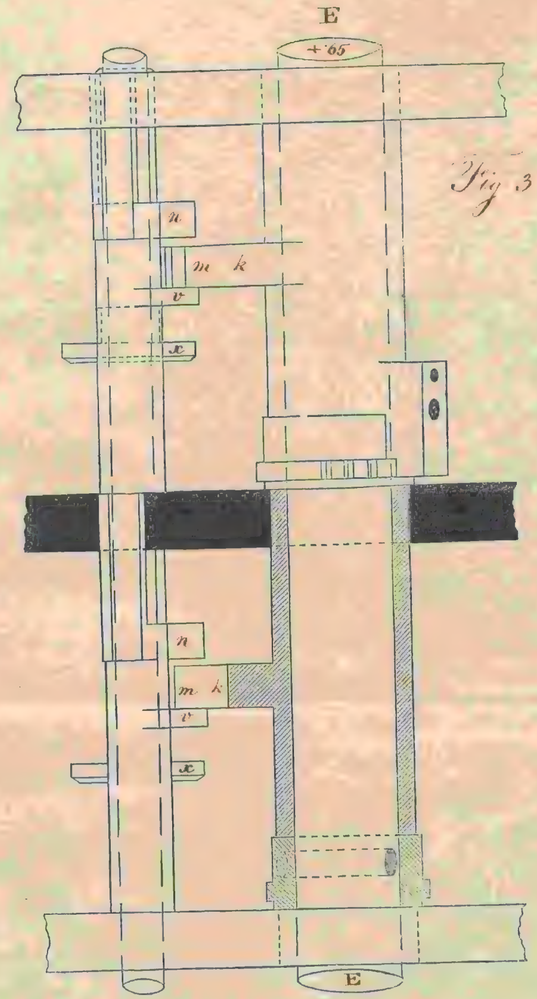
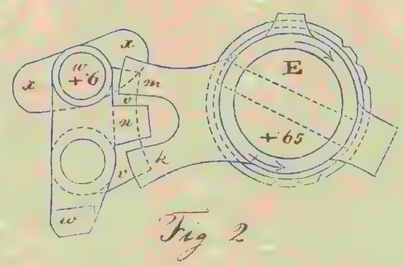
Carriage by anticipation

4 Dec. 1836







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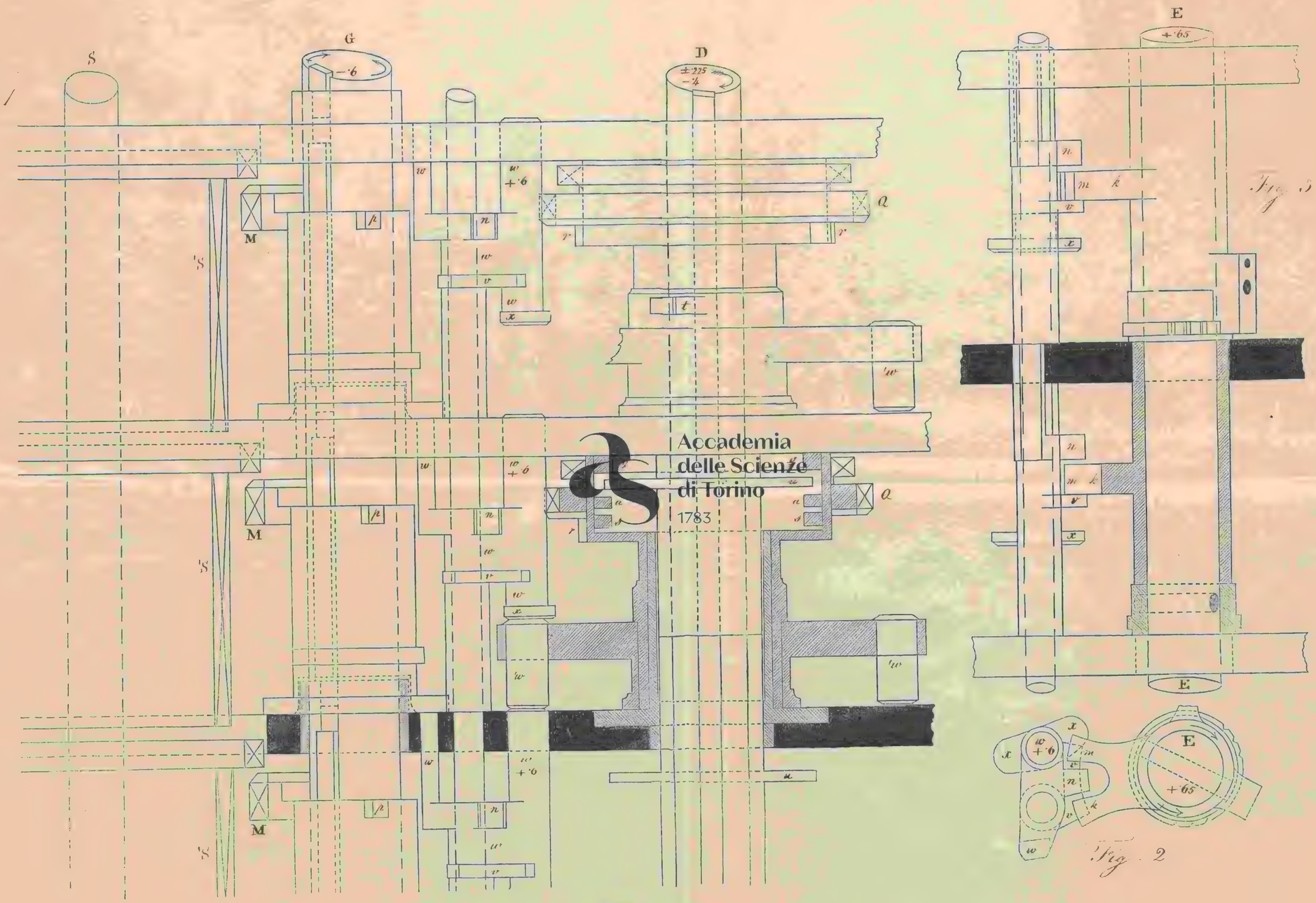
Carriage by Anticipation

4 Dec. 1836



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Babbage

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Machine à calculer

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di Torino
1783

Expt of punching on Copper for Mr
Babbage's Calculating Engine
1822

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Ex.t of punching on Copper for Mr. Babbage's Calculating Engine.

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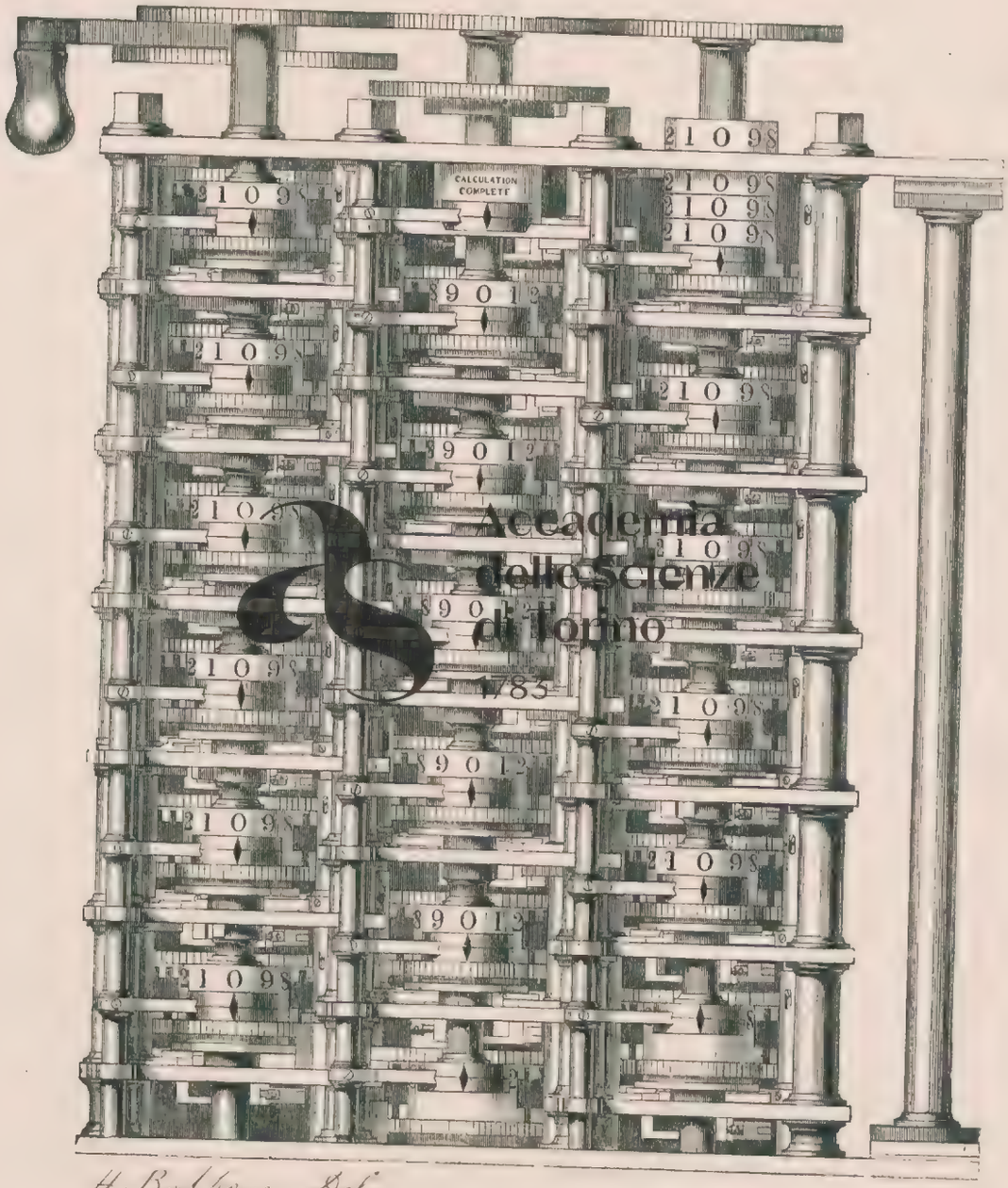
1822.



H. Babbage Del

Elevation of a portion of Mr Babbage's Engine for calculating Tables by the Method of Differences as arranged in 1834

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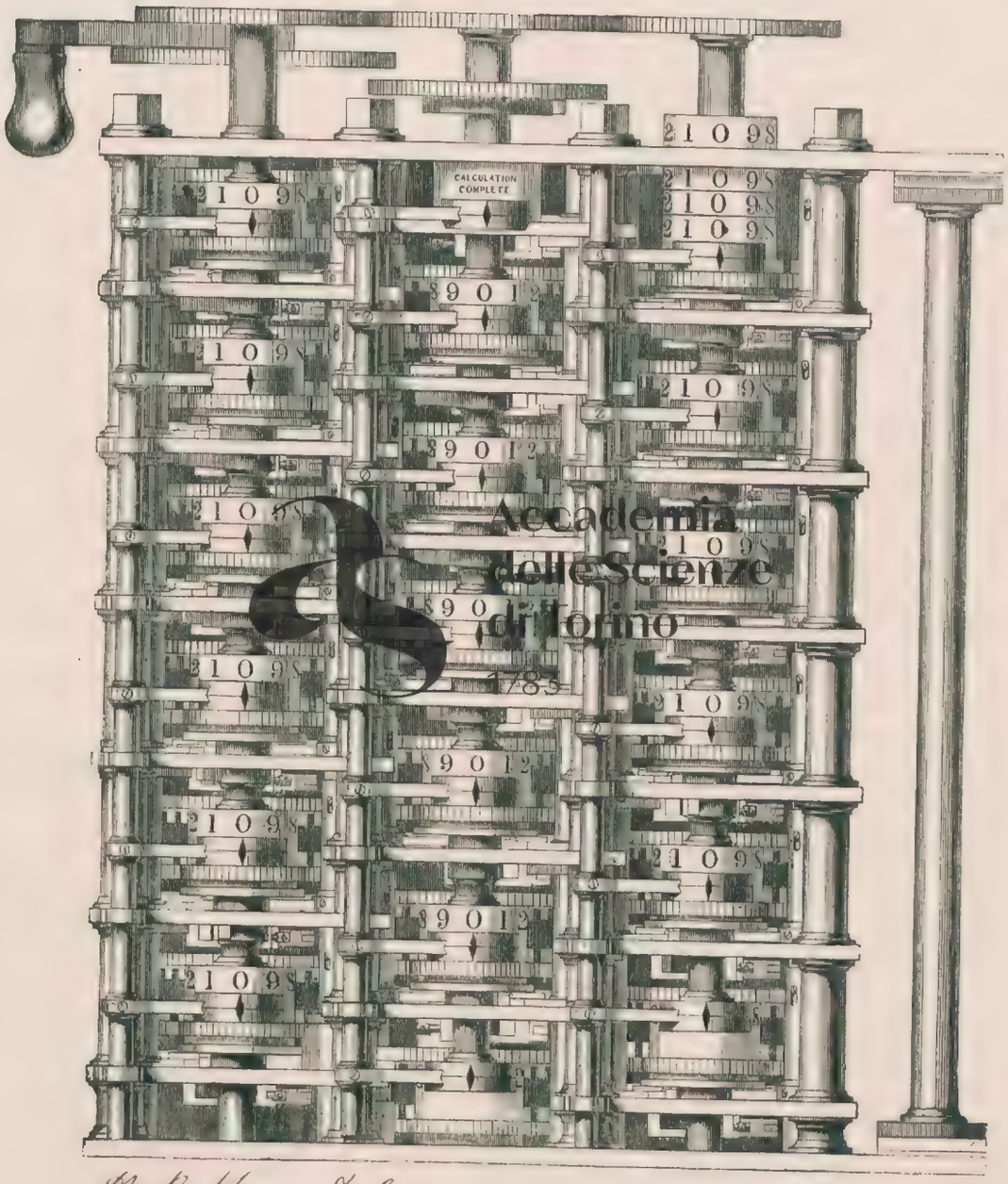

H. Babbage Del

Elevation of a portion of Mr Babbage's Engine for calculating Tables by the Method of Differences as arranged in 1834

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Note respecting the Calculating Engine

The designs of the engine are contained on upwards of 90 Drawings each three feet ~~by~~ wide by two feet high.

The Mechanical Notations by which the various movements are represented occupy about ~~four~~ hundred large sheets of paper.

The original sketches ~~in~~ directions and notes ~~fill two~~ are contained in four small volumes. A few impressions ~~from~~ from ~~about~~ twelve large wood cuts and one large engraving in stone have been taken.

Besides these there are some other volumes of Mechanical Calculations and about fifty or sixty Algebraic [illegible]

The whole of these papers are by no means necessary for the understanding or construction of the Engine. They form the history of the progress of the mind in ~~the~~ ~~Inventing~~ inventing it: and an abstract of the chief points at which definite discoveries have been made is arranged on seven large sheets of paper each divided by horizontal lines into twelve parts or months and divided into vertical columns to separate the various distinct portions of the Engine as for ex. Adding (Carrying &c

These papers will be invaluable to whoever in

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in future years may be destined to construct the Engine. They will enable him to see the reason for rejecting many improvements which occurred and the causes for which those which exist were approved — Without the possession of these papers no just idea can be formed of the quantity of thought expended in the engine ~~nor wou~~ and in all probability any one who attempted to improve it would

The design of this Calc.d Engine was commenced in Sep.ber 1834 and carried on continually with the exception of five months during which the drawings were discontinued while the author was ~~comp~~ making experiments on the Grand Western Railway

The principles on which each separate portion of the engine acts were successively discovered and their modes of application improved so that there are drawings of about 15 different mechanical contrivances for addition and a still larger number for Carriage

The general combination has undergone as many changes The two plans brought to Turin are dated Jan 1837 the 13th Gen. Plan — and August 1840 the 25th Gen. Plan.

The points most remarkable for their importance and contrivance are

1 The method of addition of which there is a model this is remarkable for its simplicity

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2 The method of carrying the tens of which there are three wood cuts a description and notation

This is remarkable for its extreme generality and for the shortness of time in its operation –

3 The principle of division and its reduction to a direct process without having more than three carriages in the whole engine –

4 The plan of communicating all orders to the engine by means of cards with perforations

This renders the number of operations as well as of variables and of given numbers absolutely unlimited without increasing the size of the Engine

The engine is drawn as if it were to have 40 figure wheels so that it can multiply any two numbers each not exceeding 40 digits and divide the product containing 80 digits by any other number of 40 figures –

If ~~more~~ calculations requiring above 40 figures are wanted the same Engine can calculate the same formulae to 80 places in 4 times the time

120 — 9 — the time

160 — 16 — the time

&c –

So that it is neither limited in extent of figures nor in the number of its variables or operations.

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$$a + bx + cy + d$$

$$X_1 + X_2 y + X_3 y^2$$

$$'X_1 + 'X_2 y + 'X_3 y^2$$

$$X_3 'X_1 + X_3 'X_2 y + X_3 'X_3 y^2$$

$$'X_3 X_1 + 'X_3 X_2 y + 'X_3 X_3 y^2$$

$$y = f(x)$$

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Method of Carrying; intended for the great Machine (Designed about 4 Dec. 1836

N.B. This is the first design in which the carrying axis G moves in two directions to carry, and is under the control of the directive.

The Anticipation of carriage is provided for by wires: the line of which is perfect or broken, according to the figure the figure wheel stands at.

The figure wheel has two sets of figures upon it, one for Addition and one for Subtraction: & the axis D brings either set to its own zero in obedience to the orders of the directive

In Addition notice of carriage is given by the highest cam on the figure wheel acting on the lever C, which moves the bops on the axis E in the direction of the additive arrow ⟶ until the arm M is under the projection n of the wire

When the Addition is finished the axis G is moved circularly in the opposite direction to that it is intended to move for the purpose of carrying, until the projection h is clear of the stop O, then by lifting the axis E with the bopes upon it the wires in those cages where notice has been given are lifted; and every wire ~~that~~ is lifted, whether by means of the arm M, or by the interposition of the short wires W carried by the figure wheel, lifts the carrying sector in the cage above it into gear with the wheel attached to the long pinion, the carrying axis then moves through such an angle that the figure wheels are moved one figure. then moves down to put the carrying sectors out of gear, then moves circularly until the projection h is under the stop O when the axis rises to its original position.

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The lever c is put into its unwarned position by the cams on the axis A which also lock the figure wheels

The process in Subtraction is similar, but by a different vertical position of the axis a 10 the lowest cam on the figure wheel acts on the arm d and moves the boss upon E in the direction of the subtractive arrow

The times of action are shewn in the Notation

Square Root requires the means of changing the sign of Carriage figure wheel without reducing it to zero

Notation

	Vertical motion of axes by Lifting Sectors	Lock Central	Lock long pin^n	Lock [illegible]	Wire Axis E Vert^l	Carrying Axis G Vert^l	Carrying Axis G Circ^r	Axis N Vert^l	Axis A Circu^r	Barrels move lineally
	--- Addition is finished in this unit of time ---									
10		↓L								
11			↓L	↓L			↑		↓	
12	↓ ↑	↑U	↑U	↑U	↑ ↓			↑ ↓	↑	
13		↓L	↓L	↓L			↓ Carry		↓	
14	↓ ↑					↓			↓ Unwarn C	
1/3									↑	↑
2/3										↓
1	↑ ↓	↑U	↑U	↑U				↑ ↓	↑	

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Tuesday 15 Sep 1840

Calculating Engine

The most general conception of this engine will scarcely be apprehended except by those who are familiar both with mechanical and mathematical science.

Those who are acquainted with the loom are aware that by means of cards having certain holes punched in them it is possible to weave with the same loom any design however complicated. The design is translated into cards and these direct the motions of the ~~warp~~ threads.

By similar means the operations of the calculating engine are directed. Any formula however complicated is translated into cards and these being placed in the Engine it works out that particular formula and gives its numerical value

In one respect however it advances beyond the cards of Jacard. For in the case of the developement of functions it backs the cards more or less so as to repeat the operations according to any assigned laws thus enabling a small number of cards to perform [illegible] the place of a great many and rendering [illegible] to effect the algebraic developement of a function in order to make the cards the laws of that developement only being communicated to the cards

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The Cards are placed on six sided prisms which revolve ~~through one or more of their sides~~ pierced with holes; they are at times caused to revolve so as to make one or more cards pass forward or backward. They have also an advancing motion by which they act on levers placed opposite to them

Reducting Apparatus

This consists of four sectors of 1, 1, 2 & 3 teeth acting on a central wheel which by means of one or of two gearings can give the barrel a circular motion in either direction of 1, 2, 3, 4, 5 teeth

Barrels

These consist of cylinders divided by a number of vertical lines into 31 Vertical spaces called Verticals these are again divided into horizontal rings - Opposite each ring are two levers one of which being advanced the other moves in the opposite direction so that they may have the three following positions

Each Vertical may have opposite every ring either one or two studs which may act on these levers

Thus each Vertical may have on it a series of studs which by means of those levers give various directions to different parts of the mill by throwing certain wheels axes and levers either into or out of gear. Some of the lowest rings on these barrels govern the reducing app either of their own or other barrels

Card Counting App.

This app. is intended to cause the prisms of the Cards to pass through a greater or less number of spaces and thus to bring any required card into that position in which it will act as soon as it is ordered to advance. It either itself computes the new girls own action (if it is simple) or it receives them from the Store in which ~~they~~ it may have already been computed.

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Decimal Counting App^s

This is a part which determines the position of the decimal point and consequently how many times the product of two factors must be stepped up or down

Running Up Levers

This is a system of levers ordering various changes which are contingent upon certain events. They sometimes order the change of one law of calculation to a different one by ~~moving cau~~ acting on the Card Counting App and moving the cards either forwards or backwards

~~Various circumstances may be made to cal~~ cause the consequences produced by these various levers will depend on the will of the constructor of the cards: but they ~~will~~ are always be called into action by the alteration of the 40th figure wheel of some carriage, which in fact corresponds to a change of sign in some quantity employed.

Examples of [illegible] time in [illegible]

$\frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \ldots$ to 100 000 terms

$\frac{2+1}{1.2} + \frac{4+3}{3.4} + \ldots$

$p(p(p+a)+b)+c$ instead of p^3+ap^2+bp+c

2 Mult.^n + 3 Add.^n (2+2+1) Mult.^n + 3 Add.^n

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In trying whether any given formula can be calculated by the Engine it must always be remembered that it was never proposed to execute by the Engine any thing which cannot be executed by pen. It was only proposed to calculate in less time and with absolute certainty. It is therefore necessary to write out the formula in the same manner by pen and then to give the laws which govern it by means of proper cards to the Engine. for Ex.

Let it be req^d to expand any function by Taylors theorem.

$$f(x+i) = f(x) + \frac{i}{1}\frac{d}{dx}f(x) + \frac{i^2}{1.2}\frac{d^2}{dx^2}f(x) + \cdots$$

and let the 1st function be $f(x) = \dfrac{a+bx+cx^2}{a'+b'x+c'x^2}$

Then the law of diff^s being known we know that

$$\frac{d^n}{dx^n}\frac{a+bx+cx^2}{a'+b'x+c'x^2} = \frac{\underset{n}{A} + \underset{n}{B}x + \underset{n}{C}x^2 + \cdots\cdots}{\underset{n}{A'} + \underset{n}{B'}x + \underset{n}{C'}x^2 + \cdots\cdots} \cdot \frac{x^{n+2}}{x^{2n+2}} = \frac{\underset{n}{A} + \underset{n}{B}x + \underset{n}{C}x^2 + \cdots}{(a'+b'x+c'x^2)^{n+1}} \cdot x^{n+2}$$

Now the law regulating the values of $A, B, \ldots A', B', \ldots$ must be next found it is deduced from the eq^n.

$$\frac{d}{dx}\cdot\frac{\underset{n}{A} + \underset{n}{B}x + \cdots}{(a'+b'x+c'x^2)^{n+1}} \cdot x^{n+2} = \frac{(\underset{n}{B} + 2\underset{n}{C}x + \cdots)(a'+b'x+c'x^2)^{n+1} - (n+1)(b'+2c'x)(\underset{n}{A} + \underset{n}{B}x + \underset{n}{C}x^2 + \cdots x^{n+2})}{(a'+b'x+c'x^2)^{n+2}}$$

$$= \frac{\underset{n+1}{A} + \underset{n+1}{B}x + \underset{n+1}{C}x^2 + \cdots\cdots}{(a'+b'x+c'x^2)^{n+2}} \cdot x^{n+3}$$

Hence $\underset{n+1}{A} + \underset{n+1}{B}x + \underset{n+1}{C}x^2 + \cdots\cdots x^{n+3} =$

$$= a'\underset{n}{B} + 2a'\underset{n}{C}x + 3a'\underset{n}{D}x^2 + \cdots x^{n+3}$$
$$+ b'\underset{n}{B} + 2b'\underset{n}{C} +$$
$$+ c'\underset{n}{B} +$$
$$\overline{n+1}\,b'\underset{n}{A} + \overline{n+1}\,b'\underset{n}{B} + \overline{n+1}\,b'\underset{n}{C} +$$
$$\overline{n+1}\,2c'\underset{n}{A} + \overline{n+1}\,2c'\underset{n}{B} +$$

or

$$\underset{n+1}{A} = a'\underset{n}{B} - \overline{n+1}\,b'\underset{n}{A}$$
$$\underset{n+1}{B} = 2a'\underset{n}{C} - n\,b'\underset{n}{B} - 2\overline{n+1}\,c'\underset{n}{A}$$
$$\underset{n+1}{C} = 3a'\underset{n}{D} - \overline{n-1}\,b'\underset{n}{C} - (2\overline{n+1}-1)c'\underset{n}{B}$$
$$\underset{n+1}{D} = 4a'\underset{n}{E} - (\overline{n+1}-3)b'\underset{n}{D} - (2\overline{n+1}-2)c'\underset{n}{C}$$
$$\underset{n+1}{E} = 5a'\underset{n}{F} - (\overline{n+1}-4)b'\underset{n}{E} - (2\overline{n+1}-3)c'\underset{n}{D}$$

From the 1st of these eq^ns putting $n=1$ we have $\underset{2}{A} = a'b - 2b'a$ also since $\underset{1}{C} = c$ we have by the 2nd $\underset{2}{B} = 2a'c - b'b - 4c'a$

Hence by 1st $\underset{3}{A} = a'(2a'c - b'b - 4c'a) - 3b'(a'b - 2b'a)$

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Mss. 2776.19)

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The Calculating Engine consists of two parts

1st The Mill which consists of a series of axes and wheels surrounding a great central column of wheels

2nd The Store which consists of a rack communicating by means of the Ingress and Egress wh.s ∥ and ∧ with the central wh.s and having a series of columns of figure wh.s marked V_1 V_2 V_3 &c. in each of which any number ~~not~~ of not more than 40 places of figures can be expressed by the inferior wh.s of each cage and any other similar number can be expressed in the superior wh.s of the same cage.

The mill has the power of performing the operations of addition and subtraction, multiplication and division and of combining the signs of the numbers employed according to the usual rules. It requires on an average

for Add.n & Sub.n minute 1/8

for Mult.n with Decimals 3

— without Decimals 2

for division 3

each Number employed having 30 places of figures

The mill has also the power of turning backward or forward any number of cards according to any laws or even arbitrary numbers which may be prescribed for it

The Store receives on each of its columns any function whatever (this must be written on a piece of paper and cannot be changed during the cal.n of the same formula) its numerical coefficient and its algebraic sign.

The Store when ordered by the advance of its Variable Cards can give up any of the numerical coefficients and their signs to the mill and receive any result with their signs from the Mill and place them on any variable

These same Variable Cards can also order the deduction to zero of any of those ~~numbers~~ coefficients and can transport any of them ~~to~~ from their own to any other column or variable. It is these ~~latter~~ powers of the Store which enable it to perform ~~algebraical~~ analytical operations and to make an unlimited series of substitutions

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When the Calc. Engine is req^d to calculate any formula for the first step is to make an algebraic notation by which the number and nature of the Operation cards as well as of those of the Variables will become known. When these cards are once made they may be replaced in the Engine at any future time and new constants being put in the machine the resultants will be calculated and printed —

The history of such calculations is thus

After the cards are put into the engine those of operation in the Mill those of the Variables in the Store and after the constants belonging to the formula have been put into the store then at the first turn of the handle the first operation card advances

This card pushes a lever which by acting on the Reducing levers causes the barrels to revolve on their axis through a certain angle dependent on the nature of the operation

If this operation is Multiplication the barrels are ordered to a certain vertical the 4th for example: they then advance and by acting upon the levers influenced by the studs on that vertical they give certain orders to prepare the mill for multiplication — ~~One of these~~ One of these orders will be through its own reducing levers to turn the barrels to a new vertical (say the 6th) another order will be to the Var. cards to advance in the next turn in order that the first factor may be given to the Mill.

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The 6th Vert. advances and the Var. cards advance at the same time This orders the first factor to be received into the mill and upon one of the carriages F It also orders itself to turn to a new vertical (the 8th) and also the Var. cards to revolve one place

The 8th Vert. ~~order~~ advances and also the next Var. card These order the second factor to be received into the Mill and to be given out from the Store. The second factor is at this turn subtracted from the first upon the axis F

If the first factor is the largest then there is no running up but if the reverse is the case then the Running up order the greatest factor to be taken and in the succeeding nine turns a table of its nine Multiples is made upon the axes F_1 F_2 . . . F_9 —

After the table is made the multiples corresponding to the several digits of the other factor are taken from the table commencing with the highest this is stepped up or in fact multiplied by 10 The mult. of the next digit is then taken and being added to this the sum is again stepped up

and 10 ~

When the multiples corresponding to the whole of the digits of the second factor are thus added together, the successive sums being each stepped up or multiplied by 10; the product must now be stepped down so as to place its decimal point at the proper height

The barrel now turns to a vertical which orders the Variable cards to advance in order that they may determine upon what variables the product must be placed. As the product of two numbers each of 20 digits may occupy two Variables it requires ~~two~~ columns

The barrel having at its last turn ~~destroyed~~ reduced to zero all the multiples and any other numbers which may remain in the Mill now orders the operation cards to advance at the next turn and orders itself to its zero point

The next oper^n card may order multiplication again or it may order Division — If it order Division then

The Reducing Sectors acting on the barrels (by order of the Op^n cards) they are turned to the third vertical which commences Divi^n

The 3rd Vert prepares the Mill for division and orders the Variable cards to advance. This [illegible] also orders the Red^g App to direct its own barrel [illegible] similarly to 5th Vert.

When the 5th Vert advances the Mill receives the divisor from the Store It then orders the [illegible] that the other succeeding vertical — These order into the Mill the Dividend which may exist upon two Variables since it may have 80 figures

The mill now commences by a peculiar Apparatus to count the number of digits in Divisor and Dividend at the same time it makes a table of the nine Multiples of the Divisor — Having ascertained the number of digits in each it steps one ~~or other~~ up to the same level as the other. It then proceeds to compare the two first figures of the Dividend with the two first of each multiple and subtracts from it that multiple which has its two first figures either equal to or next less that it. It registers this digit of the Quotient on the axis "A" This process is repeated untill the quotient is found.

But as it may sometimes occur when the two first fig^s of div^d are equal to the two first of some multiple this subtraction is too great in such cases the fact is known to the Mill by the Running up of one of the Carriage and the next figure of the quotient are registered on another set of figure wh^o ~~[illegible]~~ which are considered as ne-

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gative digits. When a new Run Up occurs the quotient figures are again registered upon the positive line

At the end of the quotient the two [illegible] the positive and the negative registered on separate sets of figure which are & united together by subtracting one from the other. In the mean time the remainder if any is transferred to the Store but if this remainder is not to be used the [illegible] card which indicates its locality in the Store is a blank card and gives no orders to any variable to receive it consequently it is reduced to zero in the Mill and does not appear in the Store. The barrels now order themselves to zero and also order the Op^n card to give them a new command.

Addition and Substraction are thus perform. The algebraic sign is ordered by card that is the mill has orders to add or subtract as the sign + or minus is directed by card. But as the numbers brought in from the Store to be operated upon may have been formed by previous processes it is possible ~~they~~ any or more of them may have the negative sign. These signs which come in with the coefficients from the Store are called the accidental [illegible] and are united in the Mill with the algebraic [illegible] then the proper arithmetical operation [illegible] and the result with its right sign transmitted to the ~~Mill~~ Store

Whilst the Mill is performing the two operations of division & Mult. the Carriage F is not occupied it is connected also with the store and by means of proper Variable Card it can (during the greater part of the time occupied by those processes) itself carry on arithmetical add^ns and sub^ns in the Store

That whilst one term of an infinite series is preparing by [illegible] the numerator and denominator of the next may be made in the Store

Or any other numerical calculations (by add^ns and sub^ns) for preparing the indices to be communicated to Card Counting Appr. made be made at such times.

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Various forms of Developement

29 July 1840

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I

$$\sum u = \frac{1}{h}\int u\,dx + Au + Bh\frac{du}{dx} + Ch^2\frac{d^2u}{dx^2} + Dh^3\frac{d^3u}{dx^3} + \&c$$

$$\frac{A}{1} + \frac{1}{1\cdot 2} = 0$$

$$\frac{B}{1} + \frac{A}{1\cdot 2} + \frac{1}{1\cdot 2\cdot 3} = 0$$

$$\frac{C}{1} + \frac{B}{1\cdot 2} + \frac{A}{1\cdot 2\cdot 3} + \frac{1}{1\cdot 2\cdot 3\cdot 4} = 0$$

$$\frac{D}{1} + \frac{C}{1\cdot 2} + \frac{B}{1\cdot 2\cdot 3} + \frac{A}{1\cdot 2\cdot 3\cdot 4} + \frac{1}{1\cdot 2\cdot 3\cdot 4\cdot 5} = 0$$

$$\&c \quad = \&c$$

II

$$\log(\alpha + \beta x + \gamma x^2 + \delta x^3 + \varepsilon x^4 + \zeta x^5 + \&c) =$$
$$A + Bx + Cx^2 + Dx^3 + Ex^4 + Fx^5 + \&c$$

$$A = \log.\alpha$$
$$1B\alpha = 1\beta$$
$$2C\alpha + 1B\beta = 2\gamma$$
$$3D\alpha + 2C\beta + 1B\gamma = 3\delta$$
$$4E\alpha + 3D\beta + 2C\gamma + 1B\delta = 4\varepsilon$$
$$5F\alpha + 4E\beta + 3D\gamma + 2C\delta + 1B\varepsilon = 5\zeta$$
$$\&c = \&c$$

III

$$e^{\alpha + \beta x + \gamma x^2 + \delta x^3 + \varepsilon x^4 + \zeta x^5 + \&c} =$$
$$A + Bx + Cx^2 + Dx^3 + Ex^4 + Fx^5 + \&c$$

$$A = e^{\alpha}$$
$$1B = 1.A\beta$$
$$2C = 2A\gamma + 1B\beta$$
$$3D = 3A\delta + 2B\gamma + 1C\beta$$
$$4E = 4A\varepsilon + 3B\delta + 2C\gamma + 1D\beta$$
$$5F = 5A\zeta + 4B\varepsilon + 3C\delta + 2D\gamma + 1E\beta$$
$$\&c = \&c$$

IV

$$(\alpha + \beta x + \gamma x^2 + \delta x^3 + \varepsilon x^4 + \zeta x^5 + \&c)^m =$$
$$A + Bx + Cx^2 + Dx^3 + Ex^4 + Fx^5 + \&c$$

$$A = \alpha^m$$
$$1B\alpha = (m-0)A\beta$$
$$2C\alpha = (m-1)B\beta + (2m-0)A\gamma$$
$$3D\alpha = (m-2)C\beta + (2m-1)B\gamma + (3m-0)A\delta$$
$$4E\alpha = (m-3)D\beta + (2m-2)C\gamma + (3m-1)B\delta + (4m-0)A\varepsilon$$
$$5F\alpha = (m-4)E\beta + (2m-3)D\gamma + (3m-2)C\delta + (4m-1)B\varepsilon + (5m-0).A\zeta$$
$$\&c = \&c$$

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V

$$(x-\alpha)(x-\beta)(x-\gamma)(x-\delta)(x+\varepsilon)\ldots = x^m + ax^{m-1} + bx^{m-2} + cx^{m-3} + \&c.$$

if
$$\mathcal{A} = \alpha + \beta + \gamma + \delta + \varepsilon + \&c$$
$$\mathcal{B} = \alpha^2 + \beta^2 + \gamma^2 + \delta^2 + \varepsilon^2 + \&c$$
$$\mathcal{C} = \alpha^3 + \beta^3 + \gamma^3 + \delta^3 + \varepsilon^3 + \&c$$
$$\mathcal{D} = \alpha^4 + \beta^4 + \gamma^4 + \delta^4 + \varepsilon^4 + \&c$$
$$\mathcal{E} = \alpha^5 + \beta^5 + \gamma^5 + \delta^5 + \varepsilon^5 + \&c$$

then

$$\mathcal{A} = -a$$
$$\mathcal{B} = -a\mathcal{A} - 2b$$
$$\mathcal{C} = -a\mathcal{B} - b\mathcal{A} - 3c$$
$$\mathcal{D} = -a\mathcal{C} - b\mathcal{B} - c\mathcal{A} - 4d$$
$$\mathcal{E} = -a\mathcal{D} - b\mathcal{C} - c\mathcal{B} - d\mathcal{A} - 5e$$
$$\&c = \&c$$

VI

$$\tan x = ax + bx^3 + cx^5 + dx^7 + \&c$$

$$1a - 1 = 0$$
$$3a - 1 = 1\cdot2\cdot3\,b$$
$$5a - 1 = 3\cdot4\cdot5\,b - 1\cdot2\cdot5\,c$$
$$7a - 1 = 5\cdot6\cdot7\,b - 3\cdot4\cdots7\,c + 1\cdot2\cdots7\,d$$
$$9a - 1 = 7\cdot8\cdot9\,b - 5\cdot6\cdots9\,c + 3\cdot4\cdots9\,d - 1\cdot2\cdots9\,e$$
$$\&c = \&c$$

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VII

$$\text{Secant } x = a + bx^2 + cx^4 + dx^6 + ex^8 + \&c.$$

$$a = 1$$
$$1\cdot2.1b = 1a$$
$$1\cdots4\,1c = 3\cdot4\cdot1b - 1a$$
$$1\cdots6\cdot1d = 3\cdots6\cdot1c - 5\cdot6\cdot1b + 1a$$
$$1\cdots8\cdot1e = 3\cdots8\cdot1d - 5\cdots8\cdot1c + 7\cdot8\cdot1b - 1a$$
$$\&c = \&c$$

VIII

$$x = a\sin x + b.\sin x^3 + c.\sin x^5 + d.\sin x^7 + e.\sin x^9 + \&c$$

$$a = 1$$
$$2\cdot1\cdot3b = 1^2a$$
$$2\cdot2\cdot5c = 3^2b$$
$$2\cdot3\cdot7d = 5^2c$$
$$2\cdot4\cdot9e = 7^2d$$
$$\&c = \&c$$

$$\frac{x}{\log(1+x)} = A + Bx + Cx^2 + Dx^3 + Ex^4 + \cdots$$

$$1 = \frac{1}{1}A$$

$$0 = \frac{1}{1}B - \frac{1}{2}A$$

$$0 = \frac{1}{1}C - \frac{1}{2}B + \frac{1}{3}A$$

$$0 = \frac{1}{1}D - \frac{1}{2}C + \frac{1}{3}B - \frac{1}{4}A$$

$$0 = \frac{1}{1}E - \frac{1}{2}D + \frac{1}{3}C - \frac{1}{4}B + \frac{1}{5}A$$

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14 Aug. 1837

N° 3

Notation

of the computation of the coefficients of the powers of x

in the developement of $\dfrac{A_0 + A_1 x + A_2 x^2 + \dots A_i x^i}{a + bx + cx^2} = \lambda_0 + \lambda_1 x + \lambda_2 x^2 + \dots \lambda_m x^m$

where $\lambda_0 = \dfrac{A_0}{a}$

$$\lambda_1 = \frac{A_1 - b\lambda_0}{a}$$

and $$\lambda_m = \frac{A_m - b\lambda_{m-1} - c\lambda_{m-2}}{a}$$

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Computation of $\lambda_0, \lambda_1, \lambda_2, \&c$ from $\frac{A_0 + A_1 x + A_2 x^2 + \dots A_i x^i}{a + bx + cx^2} = \lambda_0 + \lambda_1 x + \lambda_2 x^2 + \dots \lambda_m x^m$ where $\lambda_0 = \frac{A_0}{a}$ $\lambda_1 = \frac{A_1 - b\lambda_0}{a}$ $\lambda_m = \frac{A_m - b\lambda_{m-1} - c\lambda_{m-2}}{a}$

Number of Operation — Still Specimen — Store

			a	b	c																				
			v_1	v_2	v_3	v_4	v_5	v_6	v_7	v_8	v_9	v_{10}	v_{11}	v_{12}		v_{13}	v_{14}	v_{15}	v_{16}	v_{17}	v_{18}	v_{19}	v_{20}	v_{21}
1	÷	$\frac{A_0}{a}$	0			Com. a						λ_0	λ_0		1	λ_0	0							
2	×	$b\lambda_0$	Com. b	0				$b\lambda_0$				0			2									
3	−	$A_1 - b\lambda_0$						0		A_1					3			0						
4				a		0									4									
5	÷	$\frac{A_1}{a}$		0		Com. a				0		λ_1		λ_1	5		λ_1							
6			0	b											6									
7	×	$b\lambda_1$	Com. b	0				$b\lambda_1$				0			7									
8	×	$c\lambda_0$			0		Com. c		$c\lambda_0$				0		8									
9	−	$A_2 - b\lambda_1$						0		$A_1 - b\lambda_1$					9				0					
10	−	$A_2 - b\lambda_1 - c\lambda_0$							0	0	A_2				10									
11				a		0									11									
12	÷	$\frac{A_2}{a}$		0		Com. a					0	λ_2	λ_2		12			λ_2						
13			0	b											13									
14					0		0								14									
15	×	$b\lambda_2$	Com. b	0				$b\lambda_2$				0			15									
16	×	$c\lambda_1$			0		Com. c		$c\lambda_1$					0	16									
17	−	$A_3 - b\lambda_2$						0		$A_3 - b\lambda_2$					17					0				
18	−	$A_3 - b\lambda_2 - c\lambda_1$							0	0	A_3				18									
19				a		0									19									
20	÷	$\frac{A_3}{a}$		0		Com. a					0	λ_3		λ_3	20				λ_3					
21			0	b											21									
22					0		0								22									
23	×	$b\lambda_3$	Com. b	0				$b\lambda_3$				0			23									
24	×	$c\lambda_2$			0		Com. c		$c\lambda_2$				0		24									
25	−	$A_4 - b\lambda_3$						0		$A_4 - b\lambda_3$					25						0			
26	−	$A_4 - b\lambda_3 - c\lambda_2$							0	0	A_4				26									
27				a		0									27									
28	÷	$\frac{A_4}{a}$		0		Com. a					0	λ_4	λ_4		28					λ_4				
29			0	b											29									
30					0		0								30									
31	×	$b\lambda_4$	Com. b	0				$b\lambda_4$				0			31									
32	×	$c\lambda_3$			0		Com. c		$c\lambda_3$					0	32									
33	−	$A_5 - b\lambda_4$						0		$A_5 - b\lambda_4$					33							0		
34	−	$A_5 - b\lambda_4 - c\lambda_3$							0	0	A_5				34									
35				a		0									35									
36	÷	$\frac{A_5}{a}$		0		Com. a					0	λ_5		λ_5	36						λ_5			
37			0	b											37									
38					0		0								38									
39	×	$b\lambda_5$	Com. b	0				$b\lambda_5$				0			39									
40	×	$c\lambda_4$			0		Com. c		$c\lambda_4$				0		40									
41	−	$A_6 - b\lambda_5$						0		$A_6 - b\lambda_5$					41								0	
42	−	$A_6 - b\lambda_5 - c\lambda_4$							0	0	A_6				42							λ_6		
43				a		0					0	λ_6	λ_6		43									
44	÷	$\frac{A_6}{a}$		0		Com. a									44									
45			0	b											45									
46					0		0								46									
47	×	$b\lambda_6$		0				$b\lambda_6$				0			47									
48	×	$c\lambda_5$			0				$c\lambda_5$					0	48									
49	−	$A_7 - b\lambda_6$						0		$A_7 - b\lambda_6$					49								0	
50	−	$A_7 - b\lambda_6 - c\lambda_5$							0	0	A_7				50								λ_7	
51				a		0									51									
52		$\frac{A_7}{a}$													52									

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N° 14
7 Sep. 1837

Notation

of the Coefficients of the cosines of $n\theta$ in the product of

$$(A_0 + A_1 \cos\theta + A_2 \cos 2\theta + \ldots)(a + b\cos\theta) = \lambda_0 + \lambda_1 \cos\theta + \lambda_2 \cos 2\theta + \ldots \lambda_n \cos n\theta$$

$$\lambda_n = A_n a + (A_{n-1} + A_{n+1})\frac{b}{2}$$

When the subscript index is negative the whole quantity is zero. And when it is zero the quantity to which it belongs is not multiplied by $\frac{b}{2}$ but by b or we have $2A_0 \times \frac{b}{2}$

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Calculation of the Coefficients of the Cosines of the Multiples of θ

in $(A_0 + A_1 \cos\theta + A_2 \cos 2\theta + \dots)(a + b\cos\theta) = \left(A_0 a + \frac{A_1 b}{2}\right) + \dots \left(A_n a + \overline{A_{n-1} + A_{n+1}}\,\frac{b}{2}\right)\cos n\theta$
$= \lambda_0 + \lambda_1 \cos\theta + \dots \lambda_n \cos n\theta$

Mill

			a	$\frac{b}{2}$	A_0	A_0	A_1	A_2	A_3	A_4	A_5	A_5	A_7	A_8			
			v_1	v_2	v_{2*}	v_3	v_4	v_5	v_6	v_7	v_8	v_9	v_{10}	v_{11}	v_{11*}	v_{12}	v_{13}
1	×	aA_0	0			0											aA_0
2	×	aA_1					0										
3	×	aA_2						0									
4	×	aA_3							0								
5	×	aA_4								0							
6	×	aA_5									0						
7	×	aA_6										0					
8	×	aA_7											0				
9						A_0											
10							A_1										
11								A_2									
12									A_3								
13										A_4							
14											A_5						
15												A_5					
16													A_7				
17	×	$\frac{b}{2}A_1$	$C.A_1$	0			0								$C.\frac{b}{2}$		
18			0				A_1										
19			$\frac{b}{2}$												0		
20	+	$aA_0 + \frac{b}{2}A_1$													$C.\frac{b}{2}$	λ_0	0
21	+	$A_0 + A_2$			0	0											$2.A_0$
22	+	$2A_0 + A_2$		Comp. A_2				0									0
23	+	$A_1 + A_3$			Comp. A_3		0		0								
24				0		A_1											
25	+	$A_2 + A_4$		Comp. A_4		0				0							
26					0	A_2											
27	+	$A_3 + A_5$			Comp. A_5	0					0						
28				0		A_4											
29	+	$A_4 + A_6$		Comp. A_6		0						0					
30					0	A_5											
31	+	$A_5 + A_7$				0							0				
32				0		A_6											
33	+	$A_5 + A_8$				0								0			
34							$\frac{b}{2}$										0
35	×	$\frac{b}{2}(2A_1 + A_3)$					0	$\frac{b}{2}(0,2)$									
36	×	$\frac{b}{2}(1,3)$							$\frac{b}{2}(1,3)$								
37	×	$\frac{b}{2}(2,4)$								$\frac{b}{2}(2,4)$							
38	×	$\frac{b}{2}(3,5)$									$\frac{b}{2}(3,5)$						
39	×	$\frac{b}{2}(4,6)$										$\frac{b}{2}(4,6)$					
40	×	$\frac{b}{2}(5,7)$											$\frac{b}{2}(5,7)$				
41	×	$\frac{b}{2}(5,8)$												$\frac{b}{2}(5,8)$			
42	+	$A_1 a + (0,2)$		λ_1				0									
43	+	$A_2 a + (1,3)$			λ_2				0								
44	+	$A_3 a + (2,4)$				λ_3				0							
45	+	$A_4 a + (3,5)$					λ_4				0						
46	+	$A_5 a + (4,6)$						λ_5				0					
47	+	$A_6 a + (5,7)$							λ_6				0				
48	+	$A_7 a + (6,8)$								λ_7				0			

Store

	v_{14}	v_{15}	v_{16}	v_{17}	v_{18}	v_{19}	v_{20}	v_{21}	v_{22}	v_{23}	v_{24}	v_{25}	v_{26}	v_{27}	v_{28}	v_{29}	v_{30}
1	Comp. A_0																
2		aA_1	Comp. A_1														
3				aA_2	Comp. A_2												
4						aA_3	Com. A_3										
5								aA_4	$C.A_4$								
6										aA_5	$C.A_5$						
7												aA_6	$C.A_6$				
8														aA_7	$C.A_7$		
9	0																
10			0														
11					0												
12							0										
13									0								
14											0						
15													0				
16															0		
17	$\frac{b}{2}A_1$																
18																	
19																	
20	0																
21																	
22	$2.A_0 + A_1$																
23		$A_1 + A_3$															
24																	
25					$A_1 + A_4$												
26																	
27							$A_3 + A_5$										
28																	
29								$A_4 + A_6$									
30																	
31										$A_5 + A_7$							
32																	
33												$A_6 + A_8$					
34																	
35	0																
36			0														
37					0												
38							0										
39									0								
40											0						
41													0				
42		0															
43				0													
44						0											
45								0									
46										0							
47												0					
48														0			

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A 12

23 July 1840

Determination of z

from the three equations

$$ax + by + cz + d = 0$$
$$'ax + 'by + 'cz + 'd = 0$$
$$''ax + ''by + ''cz + ''d = 0$$

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25 july 1786

Determination of z from the three eqns

$ax + by + cz + d = 0 \qquad 'ax + 'by + 'cz + 'd = 0 \qquad ''ax + ''by + ''cz + ''d = 0$

		Eqn	x v_1	y v_2	z v_3	v_4	x v_5	y v_6	z v_7	v_8	x v_9	y v_{10}	z v_{11}	v_{12}	x v_{13}	y v_{14}	z v_{15}	v_{16}	v_{17}	v_{18}	v_{19}	v_{20}	v_{21}	v_{22}	v_{23}	v_{24}	v_{25}	v_{26}	v_{27}	v_{28}	v_{29}	v_{30}	v_{31}	v_{32}
			a	b	c	d	a	b	c	d	'a	'b	'c	'd	''a	''b	''c	''d																
1		×		0							0	'a							'ab															
2		×	0	a									0							a'b														
3		—			'ab−a'b = B														0	0														
4	Elim.n between 1 & 2 Eqns	×				0					0	'a									'ac													
5		×	0	a									0									a'c												
6		—			'ac−a'c = C																0	0												
7		×				0					0												'ad											
8		×	0											0										a'd										
9		—				'ad−a'd = D																	0	0										
10		×						0							0	'a									'ab									
11		×					0	a									0									a'b								
12		—						'ab−a'b = B																	0	0								
13	Elim.n between 1 & 3 Eqns	×							0						0	'a											'ac							
14		×					0	a										0										a'c						
15		—							'ac−a'c = C																		0	0						
16		×								0					0														'ad					
17		×					0											0												a'd				
18		—							'ad−a'd = D																				0	0				
19		×			0			0	B																						'B6			
20		×		0	B				0																							'B'6		
21	Elim.n between	—				'B6−B'6 = Y																									0	0		
22	the two	×				0		0																									B'D	
23	stupefying	×		0						0																								B'D
24	Eqns	—				'BD−B'D																										0	0	
25	Final q.	÷			0	0			$\frac{\delta}{\gamma} = z$																									

Composition

$$\begin{cases} a = v_1 = v_9 & b = v_2 = v_{10} & c = v_3 = v_{11} & d = v_4 = v_{12} \\ 'a = v_5 & 'b = v_{13} & 'c = v_6 & 'd = v_{14} \\ ''a = v_7 & ''b = v_{15} & ''c = v_8 & ''d = v_{16} \end{cases}$$

$$'v_3 - 'v_7 = v_7 \qquad ''v_1 = 'v_1 = v_1$$

$$'v_1 = 'v_{17} = v_{17} \qquad 'v_2 = 'v_{18} = v_2$$

$$'v_2 = ''v_2 \qquad 'v_3 = ''v_3$$

$$z = \frac{'v_{31}}{'v_{32}} = \frac{v_{31} - v_{30}}{v_{29} - v_{30}} = \frac{(v_2 - 'v_2 - 'v_4 \cdot 'v_3)}{('v_2 \cdot 'v_4 - 'v_4 \cdot 'v_2)} =$$

$$= \frac{('v_2 \cdot 'v_{31} - 'v_4 \cdot 'v_{31})}{('v_2 \cdot 'v_{29} - 'v_4 \cdot 'v_{29})} = \frac{(v_2 - v_{30})('v_2 v_{29} - 'v_4 v_{29}) - ('v_2 v_4 - 'v_4 v_2)(v_2 v_{31} - v_4 v_{30})}{('v_2 v_{29} - 'v_4 v_{29})('v_2 v_{29} - 'v_4 v_{29}) - ('v_2 v_4 - 'v_4 v_2)(v_2 v_{29} - v_4 v_{29})} =$$

$$\frac{(v_2 v_{29} - v_4 v_{30})('v_2 v_{29} - 'v_4 v_{29}) - ('v_2 v_4 - 'v_4 v_2)(v_2 v_{31} - v_4 v_{30})}{('v_2 v_{29} - 'v_4 v_{29})('v_2 v_{29} - 'v_4 v_{29}) - ('v_2 v_4 - 'v_4 v_2)(v_2 v_{29} - v_4 v_{29})} =$$

$$\frac{(ab - a'b)('v_2 d - 'v_4 d) - ('v_2 d - 'v_4 d)(ab - a'b)}{('v_2 c - 'v_4 c)(ab - a'b) - (ab - a'b)('v_2 c - 'v_4 c)} =$$

$$\frac{(ab - a'b)('v_2 d - 'v_4 d) - ('v_2 d - 'v_4 d)(ab - a'b)}{('v_2 c - 'v_4 c)(ab - a'b) - (ab - a'b)('v_2 c - 'v_4 c)}$$

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The above with a less number of variables

		Eqn	x	y	z																													
1		×		0							0	'a							'ab															
2		×	0	a									0							a'b														
3		—			'ab−a'b = B														0	0														
4		×			0						0	'a							'ac															
5	Elim.n between 1 & 2 Eqns	×	0	a									0							a'c														
6		—			'ac−a'c = C														0	0														
7		×				0					0								'ad															
8		×	0											0						a'd														
9		—				'ad−a'd = D													0	0														
10		×						0							0	'a			'ab															
11		×					0	a									0			a'b														
12		—						'ab−a'b = B											0	0														
13	Elim.n between 1 & 3 Eqns	×							0						0	'a			'ac															
14		×					0	a										0		a'c														
15		—							'ac−a'c = C										0	0														
16		×								0					0				'ad															
17		×					0											0		a'd														
18		—							'ad−a'd = D										0	0														
19		×			0			0	B										'B6															
20		×		0	B				0											B'6														
21	Elim.n between the two	—				'B6−B'6 = Y													0	0														
22		×				0		0											'BD															
23	stupefying	×		0						0										B'D														
24	Eqns	—				'BD−B'D = δ													0	0														
25	Final q.	÷			0	0			$\frac{\delta}{\gamma} = z$																									

$$(\overset{B}{'ab - a'b})y + (\overset{C}{'ac - ac'})z + (\overset{D}{'ad - a'd}) = 0$$

$$(\overset{B}{'ab - a'b})y + (\overset{C}{'ac - a'c})z + (\overset{D}{'ad - a'd}) = 0$$

$$(\overset{\gamma}{'B6 - B'6})z + (\overset{\delta}{'BD - B'D}) = 0$$

O'a

When a letter occurs with a number in any turn as O'a above it signifies that although the number is given off it is also retained which must be accomplished by giving its numerical complement to some other variable & in the succeeding turn by giving back the numerical complement of this complement restoring the number to its original variable

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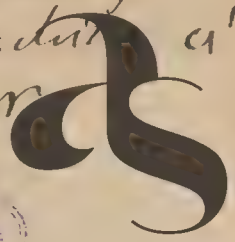
Charles Babbage,
Papiers relatifs
à la machine à
calculer



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Notation for development of

$-1\beta D + 2\gamma C + 3\delta B + 4\varepsilon A$

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$a + bx + cx^2 + dx^3 + ex^4$

$\mu x \left(\qquad\qquad\qquad\qquad + \mu e x^5 \right.$

$(k + \mu x)$ $\quad ka x^0 + a\mu x + b\mu x^2 + c\mu x^3 + d\mu x^4 + e\mu x^5$

$k\,b$

$a \cos\theta + b \cos 2\theta + c \cos 3\theta + \cdots$

~~$\mu \cos\theta$~~ $\quad f + g \cos\theta$

$a g' \cos\theta \cdot \cos\theta$ $\qquad\qquad$ $\cos(n+1)\theta \cdot \cos 2\theta =$

$\frac{\cos}{2} \cos(n+1)\theta + \frac{1}{2} \cos$

$\frac{ag}{2} \cos 2\theta + \frac{ag}{2} \cos$

$\frac{bg}{2} \cos 3\theta + \frac{bg}{2} \cos\theta$

$\frac{cg}{2} \cos 4\theta + \frac{cg}{2} \cos 2\theta$

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$$\frac{x}{\log(1+x)} = \frac{x}{\frac{x}{1} - \frac{x^2}{2} + \frac{x^3}{3} - \frac{x^4}{4} + \dots} = \alpha + \beta x + \gamma x^2 + \delta x^3 + \dots$$

$$x = \frac{1}{1}\alpha x + \frac{1}{1}\beta x^2 + \frac{1}{1}\gamma x^3 + \frac{1}{1}\delta x^4 +$$
$$- \frac{1}{2}\alpha x^2 - \frac{1}{2}\beta x^3 - \frac{1}{2}\gamma x^4 -$$
$$+ \frac{1}{3}\alpha x^3 + \frac{1}{3}\beta x^4 +$$
$$- \frac{1}{4}\alpha x^4 -$$

Law of Formation of $\frac{x}{\log(1+x)}$

$$1 = \frac{1}{1}\alpha$$
$$0 = \frac{1}{1}\beta - \frac{1}{2}\alpha$$
$$0 = \frac{1}{1}\gamma - \frac{1}{2}\beta + \frac{1}{3}\alpha$$
$$0 = \frac{1}{1}\delta - \frac{1}{2}\gamma + \frac{1}{3}\beta - \frac{1}{4}\alpha$$

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$$+3^2 = (5^2-3^2)(5^2-1)c + (7^2-3^2)(7^2-1)d$$

$$0 = 5^2(5^2-3^2)(5^2-1)c + 7^2(7^2-5^2)(7^2-1)d$$

$$-5^2 \cdot 3^2 = (7^2-5^2)(7^2-3^2)(7^2-1)d$$

$$d = -\frac{1^2}{7^2-1} \cdot \frac{3^2}{7^2-3^2} \cdot \frac{5^2}{7^2-5^2}$$

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$$-1 = (3^2-1)b + (5^2-1)c + (7^2-1)d + (9^2-1)e + \cdots$$
$$-1 = (3^4-1)b + (5^4-1)c + (7^4-1)d + (9^4-1)e$$
$$-1 = (3^6-1)b + (5^6-1)c + (7^6-1)d + (9^6-1)e$$
$$-1 = \cdots\cdots$$

$$b = \psi(3^2-1,\ 5^2-1,\ 7^2-1, \ldots) = \psi(3^4-1,\ 5^4-1,\ 7^4-1, \ldots) = \psi(3^6-1,\ 5^6-1,\ 7^6-1 \ldots) = \cdots$$

In $-1 = (3^2-1)b + (5^2-1)c + (7^2-1)d + \cdots$

if $b = \frac{-2}{3^2-1}$, $c = \frac{+2}{5^2-1}$, $d = \frac{-2}{7^2-1}$, $e = \frac{+2}{9^2-1}$

it becomes $-1 = -2 + 2 - 2 + 2 - \cdots$

which is correct if $-2+2-2+2-\&$ arises from the developement of $\frac{-2x}{1+x}$ when $x = 1$

In $-1 = (3^4-1)b + (5^4-1)c + (7^4-1)d + \cdots$

by similar reasoning

$$b = -\frac{2}{3^4-1},\quad c = \frac{2}{5^4-1},\quad d = \frac{-2}{7^4-1} \cdots \times.$$

and so on $b = -\frac{2}{3^6-1}$, $c = -\frac{2}{5^6-1}$, ...

$$b = -\frac{2}{3^8-1},\quad c = -\frac{2}{5^8-1}, \ldots$$

but this reasoning is bad because ψ & the series $-2+2-2+\cdots$ arises from dev^t of $\frac{-2x}{1+x}$

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$\cos\theta$	$+a\cos 2\theta$	$+b\cos 2\theta$	$+c\cos 3\theta$	$+d\cos 4\theta$
$\frac{ag}{2}$		$\frac{ag}{2}$		
	$\frac{bg}{2}$		$\frac{bg}{2}$	
		$\frac{cg}{2}$	$\frac{cg}{2}$	
				$\frac{dg}{2}$

$\frac{cg}{2}$

$\frac{eg}{2}$

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To Multiply $a\cos\theta + b\cos 2\theta + c\cos 3\theta + d$, by $y\cos\theta$

Mill

Store

		v_1	v_2	v_3	v_4	v_5	v_6	v_7	v_8	v_9	v_{10}	v_{11}	v_{12}	v_{13}	v_{14}	$\frac{\acute{a}c - a\acute{c}}{\acute{b}a - b\acute{a}}$
		$\acute{a}$	$\acute{b}$	$\acute{c}$	a	b	c									
×	$\acute{a}c$	0,$\acute{a}$				0,$\acute{a}$					$\acute{a}c$					
×	$a\acute{c}$			0	0,a							$a\acute{c}$				
×	$\acute{b}a$		0		0								$\acute{b}a$			
×	$b\acute{a}$	0				0								$b\acute{a}$		
−	$\acute{a}c - a\acute{c}$														$\acute{a}c - a\acute{c}$	
−	$\acute{b}a - b\acute{a}$												0	0		$\acute{b}a - b\acute{a}$
÷	$\frac{\acute{a}c - a\acute{c}}{\acute{b}a - b\acute{a}}$														0	0

$x^4 + x^5$

$(x^4 + x^3 + x^2 + bx + a) \times x^4$

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$\delta B = C$

$1B = 1A\beta$

$1.2C = 1B\beta + 1.2A\gamma$

$1.2.3D = 1.2C\beta + 1.2B\gamma + 1.2B\gamma + 1.2.3A\delta$

$3D = 1C\beta + 2B\gamma + 3A\delta$

Mode of making the Engine deduce the successive eq^ns from the Derivation of the second term $1B = 1A\beta$

$3.4E = 3D\beta + 2C\gamma$

$2.2C\gamma + 2.3B\delta$

$3B\delta + 3.4A\varepsilon$

$4E = 1D\beta + 2C\gamma + 3B\delta + 4A\varepsilon$

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$3\frac{1}{8}$ $\frac{3}{8}$

$5 \times 3 = 15$

$a^3 + pa^2 + qa + r$

$((a+p)a+q)a + r$

$3\frac{1}{8}$ $\frac{3}{8}$

$2\ 3 = 6$

$6\frac{3}{8}$

M

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$\pi = 3 \cdot 1\ 4\ 1\ 5\ 9\ 2\ 6\ 5\ 3\ 5\ 8\ 9\ 7\ 9\ 3\ 2\ 3\ 8\ 4 = \pi$

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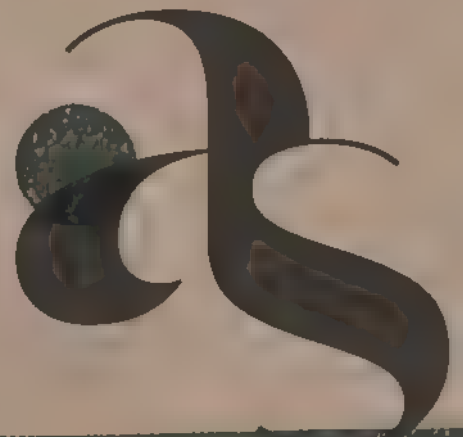

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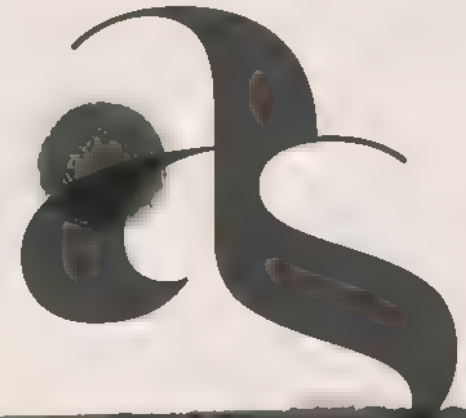

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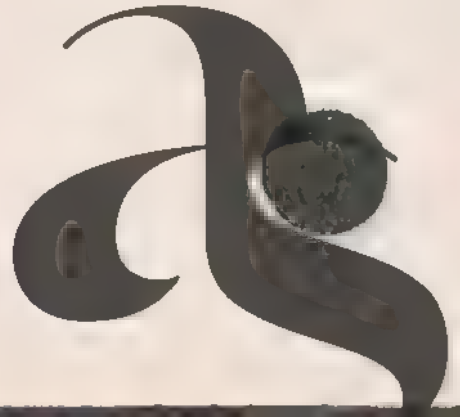

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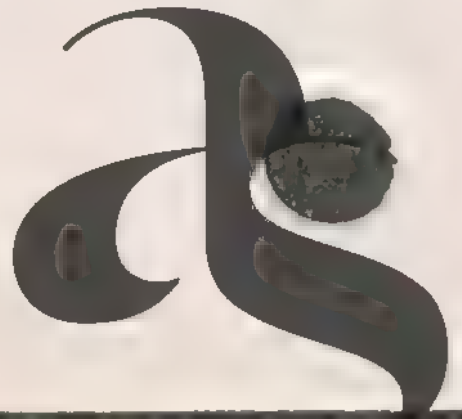

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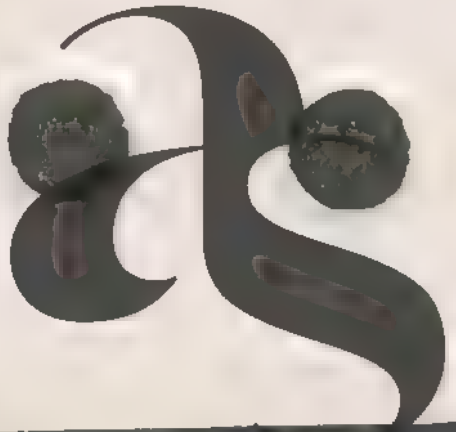

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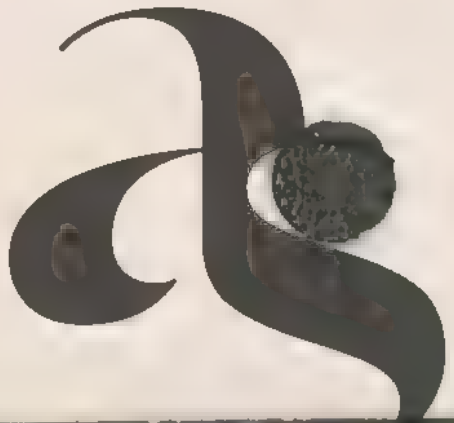

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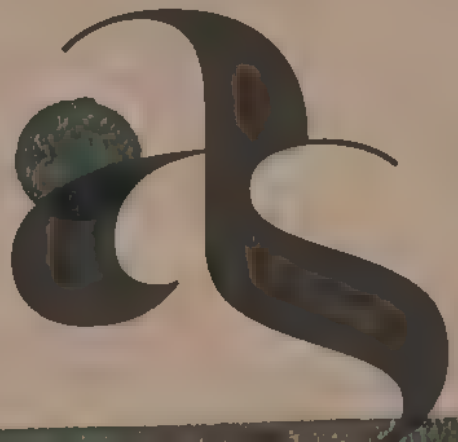

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